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# JPRS Report

# Science & Technology

## Japan

MITI'S LARGE-SCALE R&D PROJECTS REVIEWED

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[Report by the AIST Research and Development Office: "Large-Scale Projects, 1989"]

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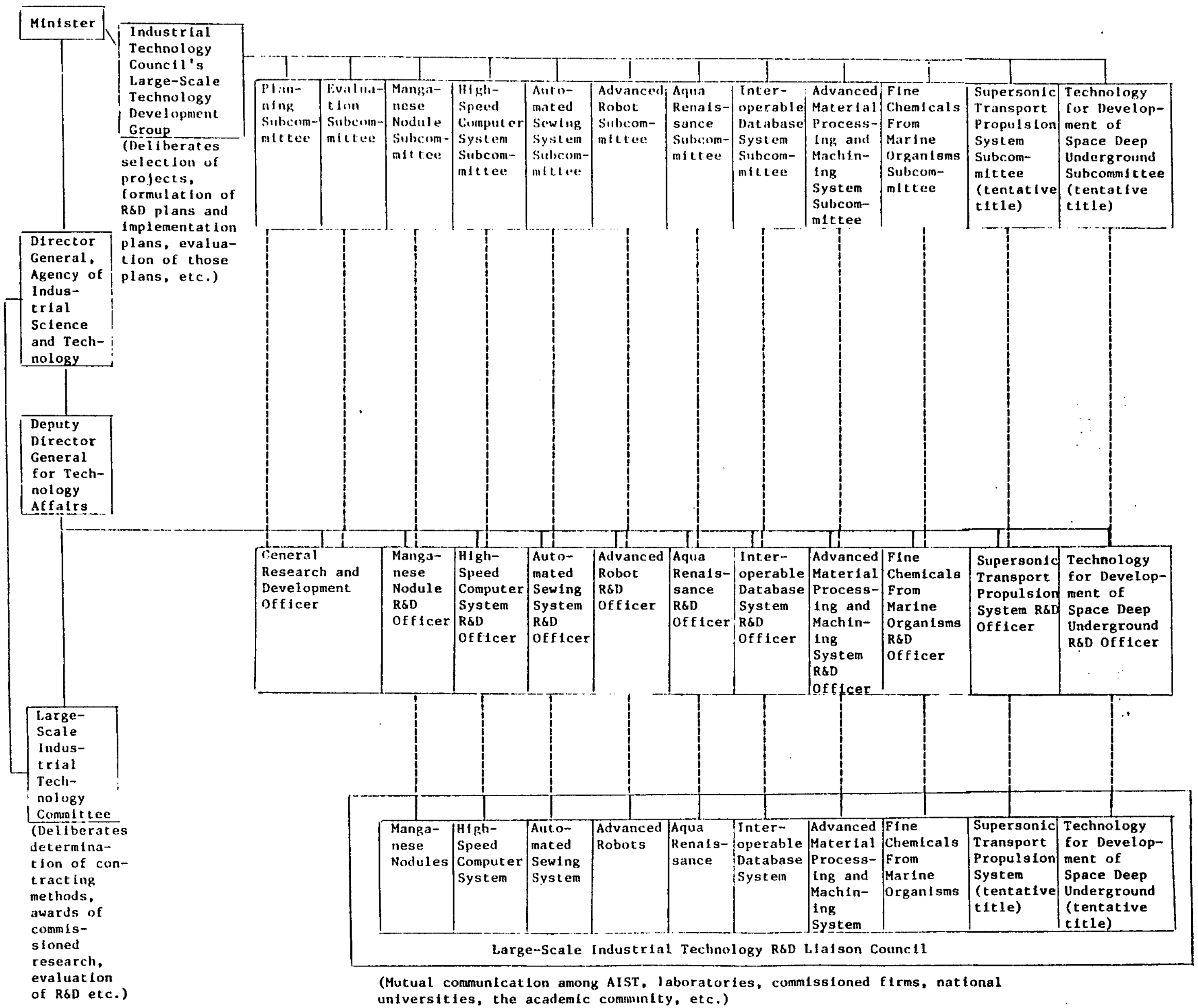
1. Outline of System

Organization of Large-Scale Project System Operations



1. Purpose and Overview of System

This system is something which deals with advanced, large-scale industrial technology that is vital and important to the national economy, and that involves R&D that cannot be carried out independently by the private sector because it requires large investments and a long period of time, and because it is accompanied by great risk. Under it, the government is responsible for the necessary investment, and planned, efficient R&D is carried out through close cooperation among the national laboratories, industry and academia.

Selection of R&D topics is made from technology that meets the conditions listed below. A topic is selected if it is recognized that R&D must be done under this system.

(1) R&D on the technology in question is very important and urgently necessary for improved industrial structure, strengthened international cooperation, rational development of natural resources or prevention of industrial pollution.

(2) It is leading technology that will have a wide-ranging effect, and the R&D will make a marked contribution to manufacturing technology.

(3) R&D on the technology in question cannot be carried out by industry because it requires large investments and a long period of time, and because it is accompanied by great risk.

(4) It is possible to set development goals for R&D on the technology in question, and there are good prospects for technical means to achieve those goals.

(5) R&D on the technology in question requires the combined R&D capabilities of the government, industry and academia.

2. History of the System

This system began in 1966 with an annual budget of about ¥1 billion for three projects: "Very High-Performance Computers," "Desulfurization Technology" and "Magneto Hydro Dynamic (MHD) Generators."

At that time the Japanese economy was being liberalized at a rapid pace, and the level of technology was rapidly rising by digesting and absorbing technology imported from Europe and the United States. However, interest and effort in development of creative technology was inadequate, and measures for R&D on a large scale, with the involvement of academic and industrial groups, was desired. This system, which joined government funding with the R&D capability of private companies, was born from such a situation.

Subsequently, the New Energy Technology Development System (Sunshine Project) and the Energy Conservation Technology Development System (Moonlight Project) branched from this system in response to the needs of the times, in

in 1974 and 1978 respectively. This system pioneered large-scale R&D in MITI, and played a central role in the promotion of R&D on advanced industrial technology.

Since that time, 25 projects (excluding "Magneto Hydro Dynamic (MHD) Generation" and "Technology for Use of Thermal Waste" which were transferred to the Moonlight Project) have been started up, and about ¥246.5 billion in government funds has been invested (as of the end of FY 1988).

3. The System and Its Operation

R&D under this system has gone forward on the basis of a setup that combines the R&D capabilities of MITI's AIST with those of industrial circles, academia and the laboratories of other government agencies. With respect to the selection of projects to be covered and the formulation of the basic R&D plans and annual implementation plans for each project, the minister of international trade and industry is to listen to entities like the Large-Scale Technology Development Group of the Industrial Technology Council, an advisory body. Implementation of the projects is to be comprehensively promoted by establishing, for each project, an R&D Liaison Committee composed of men of learning and experience and those responsible for the R&D.

The organization within the government for promotion of R&D consists of the director general of AIST, the R&D officers responsible for each project, and an overall R&D officer who handles coordination among the different projects and performs administrative functions. There is also a deputy director general for technology affairs who administers the general operation of the projects.

The implementation of the research is divided between the research done by laboratories of AIST and other government agencies and the research done by private companies.

Previously AIST had directly commissioned the private sector to do research, but the "Law on Preparation of a Research and Development System for Industrial Technology" was promulgated in October 1988; it sought to encourage and utilize research results and closer cooperation among government, industry and academia, and with other countries. In principle, research commissioned from the private sector was to be carried out through the New Energy and Industrial Technology Development Organization.

## II. Outline of Current Projects

The eight research topics continued into FY 1989 from earlier years are "Manganese Nodule Mining System," "High-Speed Computer System for Scientific and Technological Uses," "Automated Sewing System," "Advanced Robot Technology," "New Water Treatment System," "Interoperable Database System," "Advanced Material Processing and Machining System" and "Fine Chemicals From Marine Organisms." The newly begun projects are "Supersonic Transport Propulsion System" and "Technology for Development of Space Deep Underground."

The overall budget for large-scale projects in FY 1989 came to ¥13.9 billion.

Budget Summary of FY 1989 Large-Scale Projects

| Project name | Period | R&D cost (billion yen) | FY88 budget (million yen) | FY89 budget (million yen) | Implementation in 1989 |
|---|---|---|---|---|---|
| (1) Manganese Nodule Mining System | 1981-91 | 20.0 (approx.) | 954 | 1,096 | Fabrication of marine test equipment (collection, pumplift, lift tube etc.) and formulation of overall marine testing. |
| (2) High-Speed Computer System for Scientific and Technological Uses | 1981-89 | 23.0 | 2,777 | 2,431 | Research on dense integration of Josephson junctions and evaluation of parallel processing methods; construction of overall system and overall evaluation and operational testing. |
| | | | incl. *GA 736 | 341 | |
| | | | *OCISA 307 | 806 | |
| | | | *EPRSA 1,734 | 1,284 | |
| (3) Automated Sewing System | 1982-90 | 10.0 | 988 | 978 | Detailed design and fabrication of high-speed laser subsystem and three other subsystems; begin construction of test plant for some subsystems. |
| | | | *Other 880 | 875 | |
| (4) Advanced Robot Technology | 1983-90 | 20.0 | 2,479 | 2,676 | Testing of basic technology and formulation of detailed plan to verify functions of total systems for atomic power plant work robots and seabed oil production support robots; fabrication and partial coordination testing of subsystems. |
| | | | GA 290 | 269 | |
| | | | OCISA 1,007 | 1,207 | |
| | | | EPRSA 1,182 | 1,200 | |

| Project name | Period | R&D cost (billion yen) | FY88 budget (million yen) | FY89 budget (million yen) | Implementation in 1989 |
|---|---|---|---|---|---|
| (5) New Water Treatment System | 1985-90 | 11.8 | 2,189<br>GA 432<br>OCISA 1,757 | 2,528<br>377<br>2,151 | Continued R&D on microbes and membrane material; design and construction of pilot plants for high and low concentration wastes combining membrane module, bioreactor and instrumentation and controls. |
| (6) Interoperable Database System | 1985-91 | 15.0 | 1,140<br>GA 887<br>EPRSA 253 | 1,423<br>861<br>562 | Begin research and design of basic and expanded methods for distributed databases technology, multimedia technology, high-reliability technology and interoperable network system technology. |
| (7) Advanced Material Processing and Machining System | 1986-93 | 15.0 | 1,679<br>GA 356<br>EPRSA 1,323 | 2,329<br>362<br>1,967 | Continue R&D on high-power excimer laser and high-density electron beam element technology, and begin fabrication of interim demonstration devices; detailed design of total system. |
| (8) Fine Chemicals From Marine Organisms | 1988-96 | 15.0 | 20 | 275 | Collection of marine organisms in typical areas, including warm and cold currents, and preliminary research to bring about innovations in marine biotechnology, based on classification, cultivation, preservation etc. |

| Project name | Period | R&D cost (billion yen) | FY88 budget (million yen) | FY89 budget (million yen) | Implementation in 1989 |
|---|---|---|---|---|---|
| (9) Supersonic Transport Propulsion System | 1989-?? | Indefinite | 0 | 30 | Formulation of basic plan and overall plan; commencement of concept design for ramjet, high-performance turbojet and total system; preparation for full-scale R&D beginning in 1990. |
| (10) Technology for Development of Space Deep Underground | 1989-?? | Indefinite | 0 | 30 | Commencement of survey and concept design for technology for precision evaluation of underground structures, construction technology for large underground spaces, and technology to be used for fire prevention and environmental control deep underground. |
| International R&D Promotion Project | | | 5 | 4 | Promotion of international R&D on Advanced Robot Technology, a summit-related topic, in order to actively internationalize large-scale projects. |
| Office and administrative expenses | | | ** 1,321<br>GA 243<br>OCISA 1,078 | 67 | Promotion of management to effectively push projects forward; coordination. |
| Total | | | 13,550 | 13,868 | |
| | | | incl. GA 4,029 | 3,816 | |
| | | | OCISA 4,149 | 4,164 | |
| | | | EPRSA 4,492 | 5,012 | |
| | | | Other 880 | 875 | |

* GA: General Account; OCISA: Oil-Coal Industry Special Account; EPRSA: Special Account for Promotion of Electric Power Resources Development; Other: funds budgeted to Small and Medium Enterprise Agency.

** Includes "Observation System for Earth Resources Satellite," a project completed in FY 1988.

Research Schedule and Budget Trends of Current Projects
(Unit: ¥100 million)

| Project name | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Manganese Nodule Mining System | 0.5 | 8.8 | 12.0 | 13.7 | 10.8 | 9.6 | 8.2 | 9.5 | 11.0 | | | | |
| (2) High-Speed Computer System for Scientific and Technological Uses | 0.3 | 8.1 | 15.7 | 22.5 | 25.1 | 28.9 | 29.5 | 27.8 | 24.3 | | | | |
| (3) Automated Sewing System | | 0.3 | 4.0 | 10.0 | 12.2 | 13.4 | 13.0 | 9.9 | 9.8 | | | | |
| (4) Advanced Robot Technology | | | 0.4 | 7.8 | 19.0 | 24.1 | 24.2 | 24.8 | 26.8 | | | | |
| (5) New Water Treatment System | | | | | 0.2 | 10.7 | 21.2 | 21.9 | 25.3 | | | | |
| (6) Interoperable Database System | | | | | 0.2 | 8.3 | 10.5 | 11.4 | 14.2 | | | | |
| (7) Advanced Material Processing and Machining System | | | | | | 0.2 | 11.0 | 16.8 | 23.3 | | | | |
| (8) Fine Chemicals From Marine Organisms | | | | | | | | 0.2 | 2.8 | | | | |
| (9) Supersonic Transport Propulsion System | | | | | | | | | 0.3 | | | | |
| (10) Technology for Development of Space Deep Underground | | | | | | | | | 0.3 | | | | |
| Total budget for large-scale projects | 168 | 163 | 160 | 116 | 147 | 152 | 151 | 136 | 139 | | | | |

## Manganese Nodule Mining System

R&D period FY 1981-91
R&D cost approximately ¥20 billion

### Background and Purpose of R&D

The manganese nodules spread in large quantities on the deep seabed are rich in nickel, copper, cobalt, manganese and other nonferrous metals. The development of manganese nodules, which will have the nature of a purely domestic resource unaffected by resource nationalism, will be of great significance in terms of securing a stable supply for Japan, which has few nonferrous metal resources.

The development of manganese nodules is divided into the three stages of prospecting, mining and refining. Of these, the mining of manganese nodules that are spread on the seabed in depths of 4,000 to 6,000 meters will require development of completely new system and unprecedented technology.

Under the UN Law of the Seas Treaty, acquisition of developmental mining districts is predicated on possession of mining technology and transfer of technology to international organizations, so it will be necessary for Japan to develop its own technology in order to develop manganese nodules.

The marine development industry has been given the status as one of the advanced industries that will support the future of Japan. But on that point, the mining of manganese nodules spread on the deep seabed will require development of high-level technology different from that used in shallower waters. Consequently, it is thought that this research will contribute to raising the general level of marine development technology.

For these reasons it was decided to carry out R&D on a "Manganese Nodule Mining System," with the goal of establishing technology for mining manganese nodules.

### Outline of R&D

This R&D will develop mining system technology to mine the manganese nodules spread on the deep seabed by means of the highly efficient and highly reliable fluid dredging method.

(1) The system consists of a total system and four subsystems: the collection system, the lifting system, the handling system and the instrumentation control system. The subsystems are to be integrated to complete a coordinated mining system.

(2) Within the total system, there has been work on the concept design and R&D on industrial technology including system operation technology, management technology and maintenance and safety technology, and the test plan for overall marine testing has been formulated. Within the subsystems, the concept design will be followed by development of element technology and

testing to confirm functions, and the basic design of equipment for overall marine testing will be done.

(3) Based on the results of (2) above, the detailed design and fabrication of the test equipment will take place, and the overall marine testing will take place in waters off Hawaii. That will confirm mining capability, reliability, coordination among subsystems, operating technology and so on, and establish the necessary technology for a commercial production system.

The subsystems have the following primary functions.

(1) Collection System

This will gather manganese nodules and deliver them to the lift tube while moving along the soft surface of the seabed at depths of 4,000 to 6,000 meters.

(2) Lifting System

This is a system to lift the manganese nodules gathered by the collection device straight up to the mining ship; it consists of the lift tube and the slurry pump (there are both pump lift and air lift methods).

The lift tube is the route that conveys the manganese nodules from the seabed to the mining ship. At the same time, it functions as a means to tow the collection device.

The pump lift method uses pumps in the water distributed along the lift tube, and the air lift method supplies compressed air from the ship to the tube. Both generate a conveyor flow necessary to lift the minerals.

(3) Handling System

This suspends the underwater equipment (the collection and lift systems) from the mining ship and tows it, as well as lowering and raising it.

(4) Instrumentation and Control System

This provides comprehensive instrumentation, monitoring and control of various systems from the seabed to the mining ship, in order to carry out mining operations smoothly, safely and efficiently.

Major Accomplishments

By FY 1985 the basic design of the total system and the various subsystems was completed, along with design of element technology development and overall marine testing equipment; equipment to test the lifting of manganese nodules at a depth of 200 meters was completed, and liftability testing using the pump lift and air lift methods had succeeded.

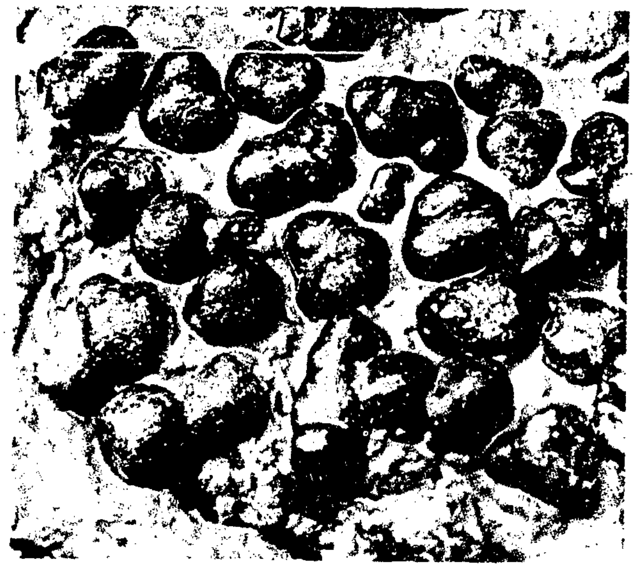


Figure 2. Manganese Nodules From the Seabed

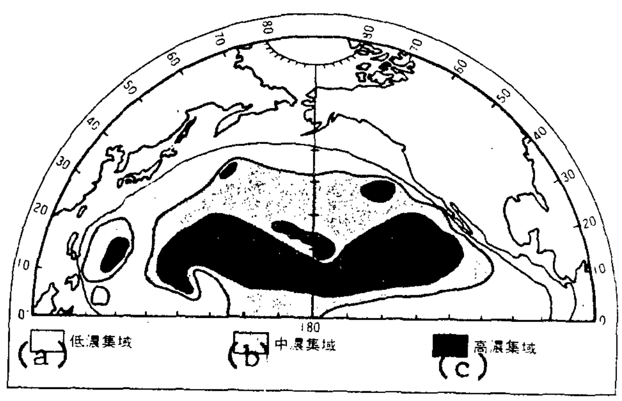
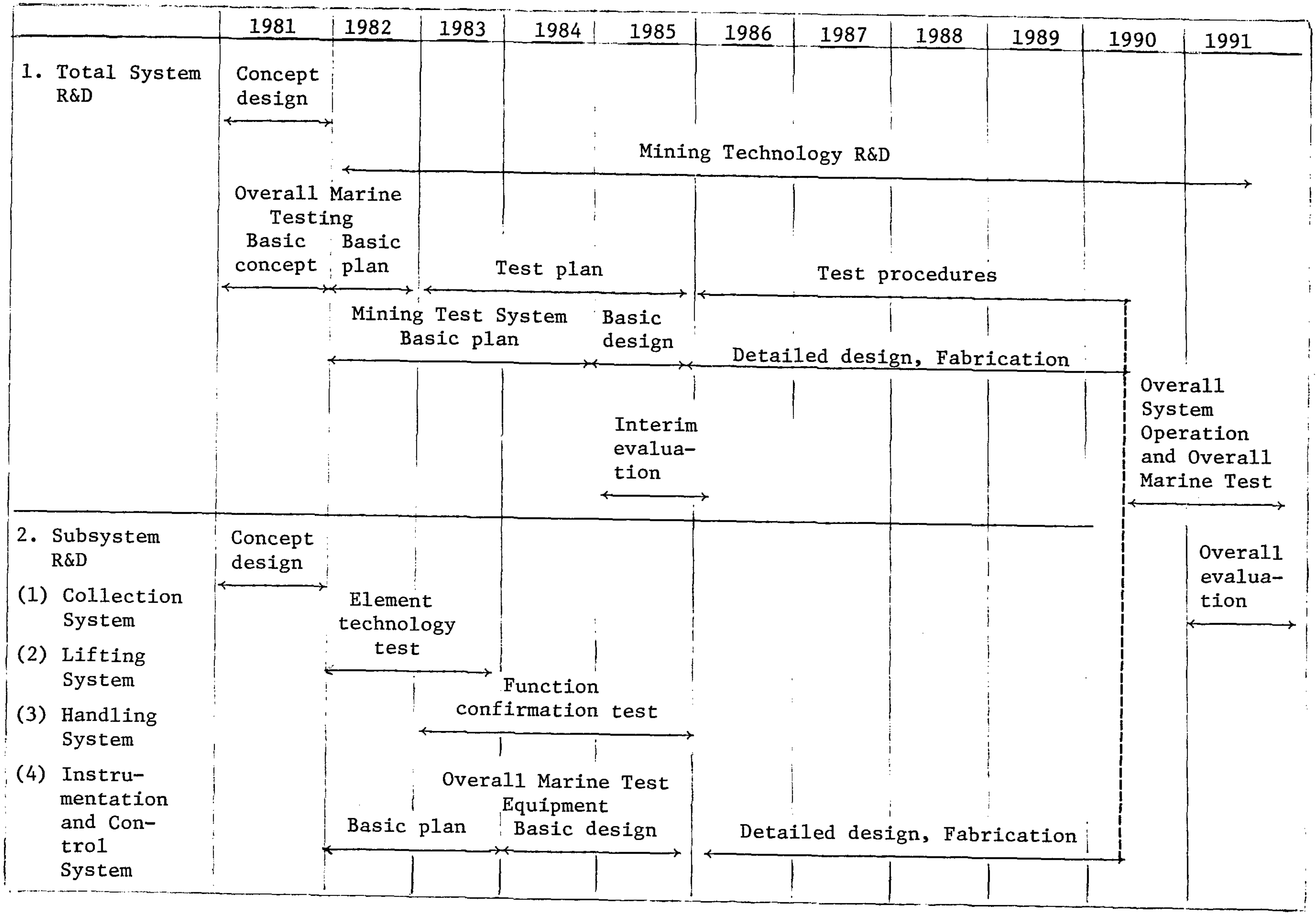



Figure 3. Distribution of Manganese Nodules in the Pacific Ocean

Key:
- a. Light concentration
- b. Medium concentration
- c. Heavy concentration

R&D Schedule


1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1. Total System R&D
Concept design
Mining Technology R&D
Overall Marine Testing
Basic concept
Basic plan
Test plan
Test procedures
Mining Test System Basic plan
Basic design
Detailed design, Fabrication
Interim evalua-tion
Overall System Operation and Overall Marine Test
2. Subsystem R&D
(1) Collection System
(2) Lifting System
(3) Handling System
(4) Instru-mentation and Con-trol System
Concept design
Element technology test
Function confirmation test
Overall Marine Test Equipment
Basic plan
Basic design
Detailed design, Fabrication
Overall evalua-tion

## High-Speed Computer System for Scientific and Technological Uses

R&D period FY 1981-89
R&D cost approximately ¥23 billion

### Background and Purpose of R&D

It has become necessary to do calculations on a large scale in various fields of science and technology, such as rapid processing of large volumes of data like the imagery data sent from artificial satellites, predictive calculation of long-range weather forecasts, and computer simulations that model nuclear reactions inside atomic reactors, the behavior of plasma in fusion reactors and the aerodynamic characteristics of aircraft.

For these reasons R&D has been done on a "High-Speed Computer System for Scientific and Technological Uses," with the goal of processing, within periods of practical significance, calculations that cannot be processed with current computers.

### Outline of R&D

This project is to develop a computer system with performance of at least 10 gigaFLOPS (FLOPS is a unit indicating how many floating point operations a computer can process in 1 second). The approaches taken to achieve that goal are R&D on fast, new logic and memory devices to replace silicon devices, R&D on method of parallel processing to operate a number of basic processors simultaneously, and R&D on an overall system to make use of these fast, new devices and the parallel processing method.

#### (1) Research on Fast Logic and Memory Devices

Speeding up logic devices and memory devices is indispensable for increasing the processing speed of computers. The methods for making faster devices are increasing the mobility of electrons and shortening the distances they move (integration).

The silicon semiconductor devices for fast operations used in current computers have nearly reached the limits of their speed. Moreover, increases in the degree of integration bring increased generation of heat due to dissipation of power in the device; the limits of integration are also being reached because of the difficulty of cooling silicon devices.

To break out of this situation, it is necessary to develop fast, new devices of materials with high electron mobility and low power consumption. For that purpose, this project has conducted research on technology for large-scale integration (LSI technology) of Josephson junction (JJ) devices using the phenomenon of superconductivity, high electron mobility transistor (HEMT) devices, and gallium arsenide (GaAs) field effect transistor devices as possible replacements for silicon devices.

(2) Research on Parallel Processing

Just changing computers from the current silicon devices to new devices is not considered adequate to achieve the processing speeds needed in the fields of scientific and technological calculation for faster processing of large amounts of data or for larger-scale computation.

In order to obtain an adequate processing speed, it is necessary to have a number of basic processors and operate them simultaneously. Research on a parallel processing method to achieve that is being done, as is research on an architecture and software to use this parallel processing efficiently.

(3) Research on Overall System

The major equipment in the overall system will be parallel processing equipment for high-speed calculation, memory equipment with large capacity and high speed, and parallel processing equipment for distributed processing. These will use the fast, new devices and parallel processing method, and performance of this major equipment will be maximized by the addition of a front-end processor, high-speed disk drives and other peripheral equipment to complete the overall system that will undergo overall evaluation and operation test.

Major Accomplishments

Research on material processing technology and LSI technology has been done through design and fabrication of experimental chips with JJ, HEMT and GaAs devices. Such things as the world's fastest 3K JJ gate array, a 4K GaAs static RAM and a 16K HEMT static RAM have been fabricated.

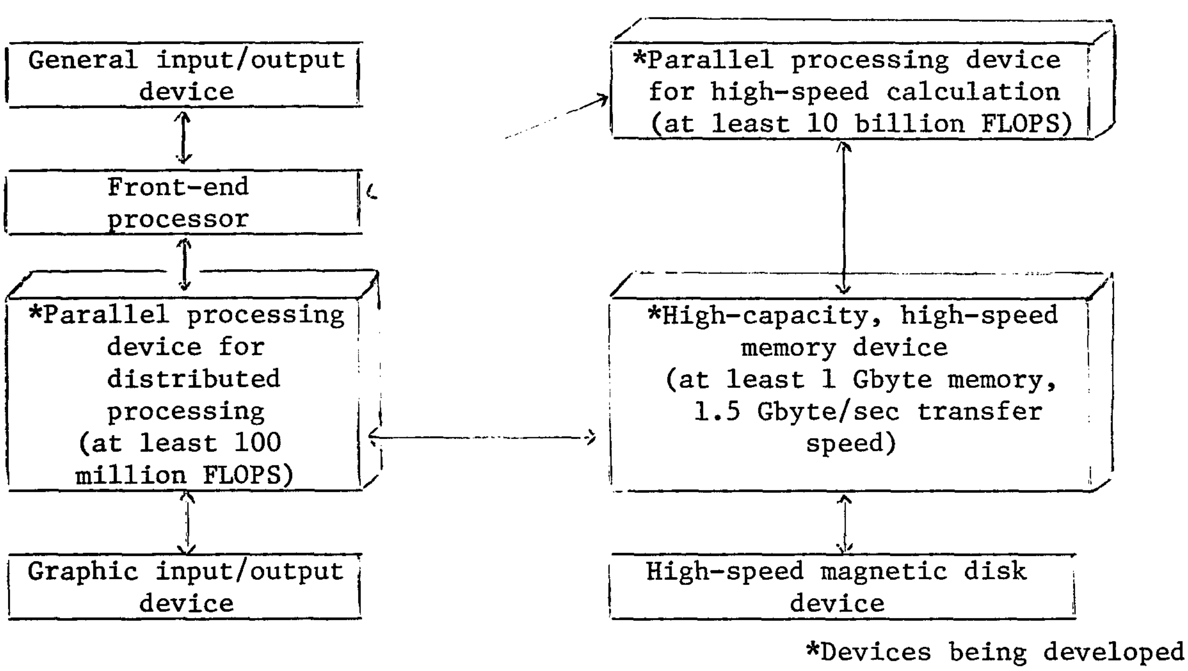
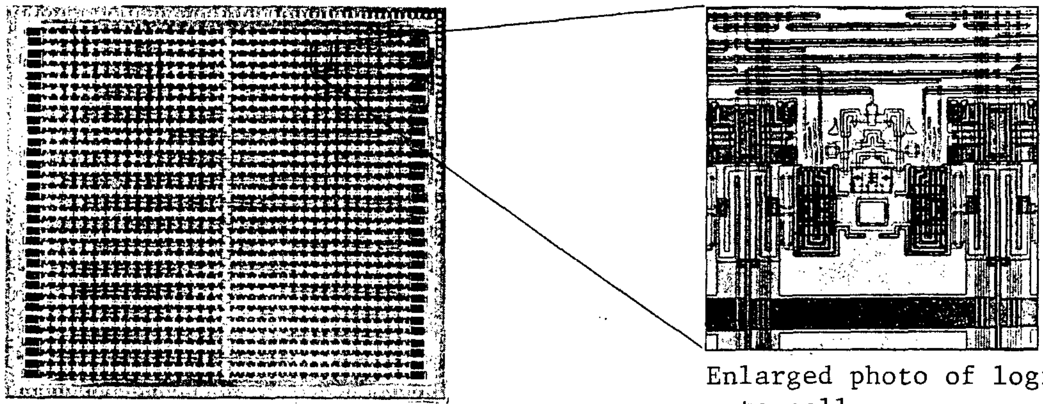



Figure 1. Block Diagram of High-Speed Computer System for Scientific and Technological Use



Enlarged photo of logic gate cell

Chip size: 9 mm x 10 mm
Junction material: Nb/A 10x/Nb
Junction size: 1.5 micron square
Junctions used: 22,848

Figure 2. 3K Josephson Logic Gate Array

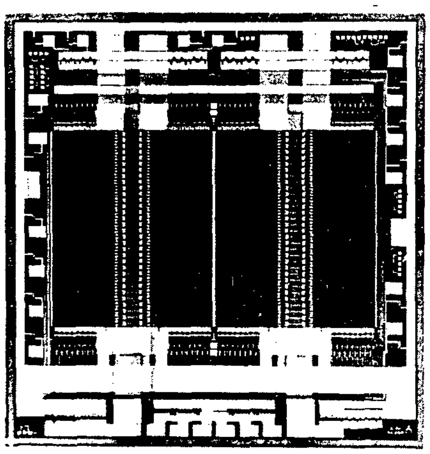


Figure 3. 4K GaAs SRAM

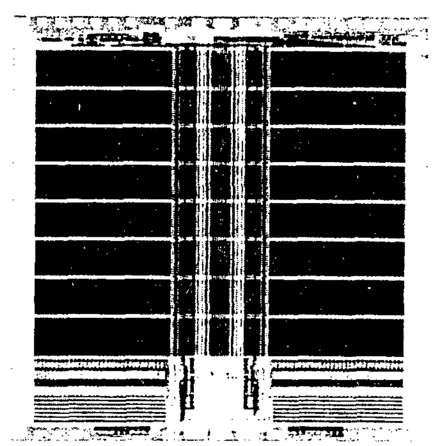


Figure 4. 16K HEMT SRAM

Device Development Targets

| | JJ device | HEMT device | GaAs device |
|---|---|---|---|
| Operating temperature | Liquid helium (-269°C) | Liquid nitrogen (-196°C) | Room temperature (about 20°C) |
| Logic device | Integration of at least 3,000 gates per chip with no more than 10 picoseconds delay time | | At least 3,000 gates, no more than 30 picoseconds delay |
| Memory device | At least 3,000 gates, no more than 10 picoseconds delay | | At least 3,000 gates, no more than 10 picoseconds delay |

R&D Schedule

| | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 |
|---|---|---|---|---|---|---|---|---|---|
| 1. Research on fast logic and memory devices | JJ device basic study | Materials and process technology | | LSI technology | | High-performance technology | | | |
| | HEMT device basic study | Materials and process technology | | LSI technology | | High-performance technology | | | |
| | GaAs device basic study | Materials and process technology | | LSI technology | | High-performance technology | | | |
| 2. Research on parallel processing | | | Parallel processing architecture basic study | Basic specifications | | Logic design | Fabrication, operation, evaluation | | |
| | Parallel processing basic study | | Parallel processing hardware basic study | Logic specifications | | Basic design | Detailed design | Coding and debugging | |
| 3. Research on overall system | | | | High-speed computer parallel processors; large-scale, high-speed memory; parallel processors for distributed processing | | | | | |
| | | | | Basic specifications | | Basic design | Detailed design | Fab., oper., evaluation | |

[Passage omitted]

## Advanced Robot Technology

R&D period FY 1983-90
R&D cost approximately ¥20 billion

### Background and Purpose of R&D

There are, in companies today, many jobs that cannot be done without adequate protections to maintain safety, and jobs where direct access by humans is not possible. Work done under heavy radiation in the atomic energy industry, work done at great depths like oil drilling and the work of fire-fighting and rescue in disasters are examples of that. Such work is indispensable for the development of economic society, and its importance is increasing; ways to do such work with automation and robots are in demand.

The goal of this project is to develop "Advanced Robot Technology" in the form of advanced work systems that can do complex jobs in place of humans in extreme environments that would be too harsh for humans. That will contribute to the safe and stable supply of energy resources, improved economic factors and a better labor climate.

### Outline of R&D

The systems to be developed under this project are human/robot systems with mechanized mobility that are highly adaptive to environments and that can be controlled quickly and accurately from safe distances.

In the first phase, R&D will be divided between sector-specific element technology that is unique to the atomic energy, marine and disaster fields, and basic technology that is common to all three.

In the second phase, the fruits of the first phase will be used to develop specialized functions in line with the individual needs of the atomic energy, marine and disaster fields.

1. Total System

(1) Work Robots for Operating Atomic Power Plants

For atomic power plants and other facilities related to atomic energy, robots will be developed to move about in the work environment and perform inspection, repairs and high-level operations on atomic energy plant equipment and facilities, with the support of remote operators.

(2) Undersea Petroleum Production Support Robots

For facilities related to marine oil development, robots will be developed to move through the sea in three dimensions while remaining in a position and attitude to do work, and to perform inspection, repairs and high-level operations, with the support of remote operators.

(3) Robots To Fight Disasters in Petroleum Production Facilities

For petroleum production facilities, robots will be developed that can move to and through the scene of disasters that have occurred, and perform high-level work to comprehend disaster conditions, prevent the spread of disasters and perform rescues, with the support of remote operators.

2. R&D on Element Technology

(1) Sector-Specific Technology

a. Atomic energy work robots

(a) Radiation hardening technology
(b) Environmental adaption technology
(c) High reliability technology

b. Marine oil development support robots

(a) Marine movement and position maintenance technology
(b) Marine vision technology
(c) Marine manipulation technology
(d) Management and control technology, etc.

c. Disaster prevention robots

(a) Durability technology
(b) Search technology
(c) Response technology

(2) Basic Technology

(a) Sensor Technology

R&D is being done on visual and tactile sensors to output information on the environment, and on technology to accurately understand the environment by efficiently processing the information obtained from those sensors.

(b) Movement Technology

R&D is being done on technology to enable efficient movement of robots in response to external environmental conditions, using such structures as legs and wheels.

(c) Manipulation Technology

R&D is being done on technology to make up manipulators capable of complex operations with dynamic control, and technology for multi-articulated and multi-fingered manipulators.

(d) Control Technology

R&D is being done on autonomous control technology for autonomous operation of robots, on "remote presence" control technology that allows an operator to control the robot with a sense of being on the scene and on intelligent remote control technology to effectively control autonomous robots.

(e) Support Technology

R&D is being done on systemization methods, including distributed processing with multiple robots, and on robot language and evaluation methods for robots that operate in extreme conditions.

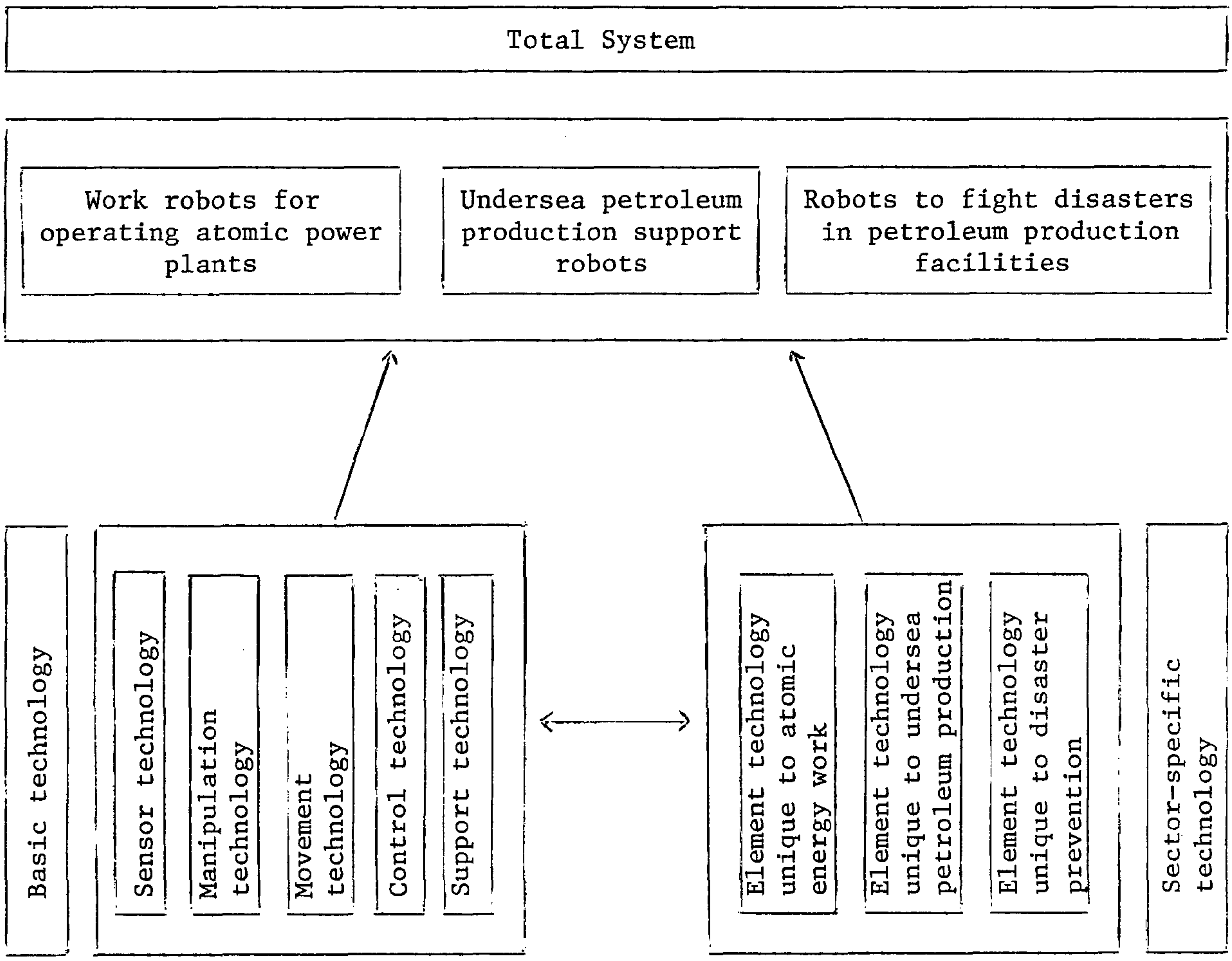



Figure 1. Total System of R&D

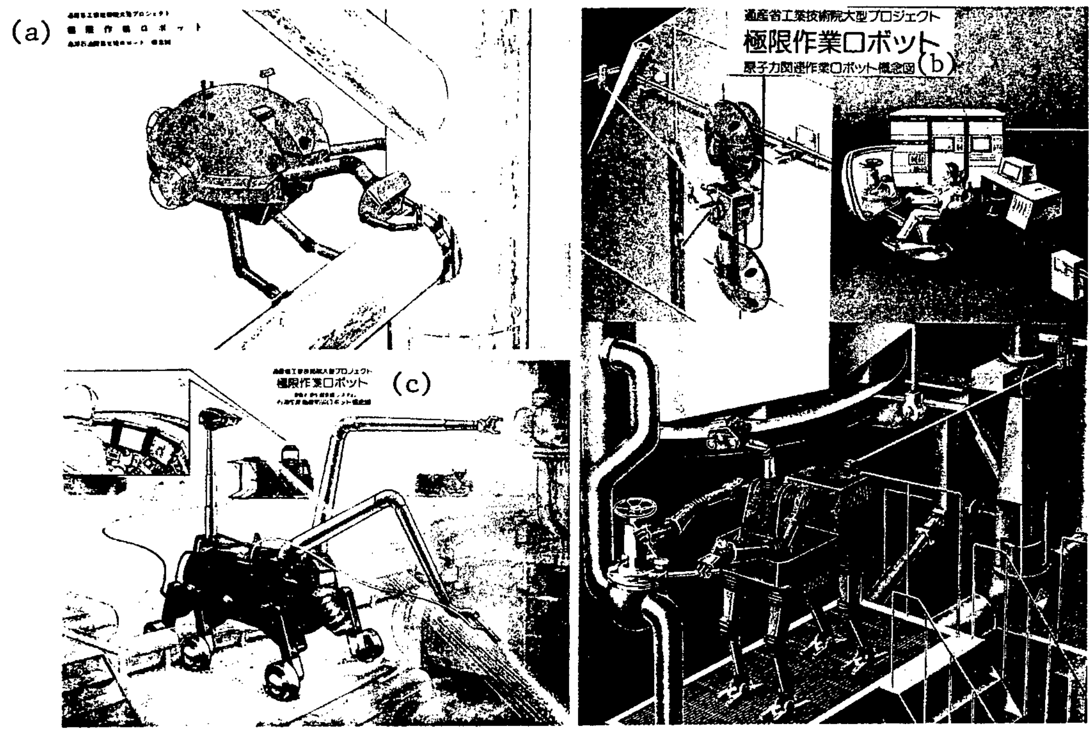



Figure 2. Artist's Conception of Advanced Robots

Key:

a. Marine oil development support robot
b. Atomic energy work robots
c. Disaster prevention robot

R&D Schedule

| | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|
| Work robots for operating atomic power plants<br>Unique element technology | | Concept & basic design | Fabrication and testing | | | Fabrication and testing | | |
| Total system | | | | Concept formulation | Concept design | Detailed design | Fab. and testing | |
| Undersea petroleum production support robots<br>Unique element technology | | | Concept & basic design | Fab. & testing | | Fabrication and testing | | |
| Total system | | | | | Concept design | Detailed design | Fab. and testing | |
| Robots to fight disasters in petroleum production facilities<br>Unique element technology | | | Concept & basic design | Fab. & testing | | Fabrication and testing | | |
| Total system | | | | | Concept design | Detailed design | Fab. and testing | |
| Basic technology<br>Mechanical, control and support technology | Basic technology development | | | | | Confirmation of technology | | |
| | | | | | Interim evaluation | | | Overall evaluation |

New Water Treatment System

R&D period FY 1985-90
R&D cost approximately ¥11.8 billion

Background and Purpose of R&D

To deal with the medium to long-term trend of tight supply and demand conditions for water, it is necessary that industrial and domestic waste water be highly processed and reused as a new water resource. To accomplish that, however, it is urgent that we solve such problems as securing sites for treatment facilities and for final disposal of sludge, and the expanding consumption of energy that accompanies high-level processing.

Japan has scant natural energy resources, and the weakest energy supply structure of all the advanced countries. But to reduce the future dependence on oil of Japan's economic community, it will be necessary to establish new technology that can provide a stable supply of inexpensive energy as an alternative to petroleum. To meet that need, we are conducting R&D on the "New Water Treatment System" (Aqua-Renaissance '90) using biotechnology and membrane separation technology.

Outline of R&D

In this project, R&D is being done on a system that will use microbes to break down contaminants in waste water, then separate remaining materials from the clean water with high-performance separation membranes.

The following are the primary items for R&D:

(1) Microbe R&D

Technology to isolate strains of microbes for methane fermentation, oxygen fermentation and nitrification, and technology to cultivate them in high concentrations and maintain them in mixed microbe systems.

(2) Film Materials R&D

Technology to select and develop organic and inorganic materials that are strong against the contaminant load, that will not be weakened by the microbes and that will endure long periods of use, and to process them into membrane surfaces.

(3) Water Treatment Reactor R&D

Technology to remove the nitrogen component from waste water so that it can be treated and reused, and reclamation technology to deal with organic contaminants.

(4) Development of Film Module for Methane Fermentation

Technology for development of a membrane nodule that requires little power per unit of water passed, that is easy to clean, and that has the effect of making fermentation efficient by maintaining a high concentration of microbes involved in methane fermentation.

(5) Development of New Type of Bioreactor for Methane Fermentation

Technology for development of a bioreactor that will make it possible to produce methane efficiently using microbes in high concentrations.

(6) Development of Methane Fermentation Instrumentation and Control System

Technology for optimum control of methane fermentation, in which such things as the activity of microbes is measured directly and the system is controlled automatically on the basis of those measurements.

(7) Total System R&D

Combination of the element technologies and verification testing in a pilot plant to ferment methane and reclaim water most efficiently.

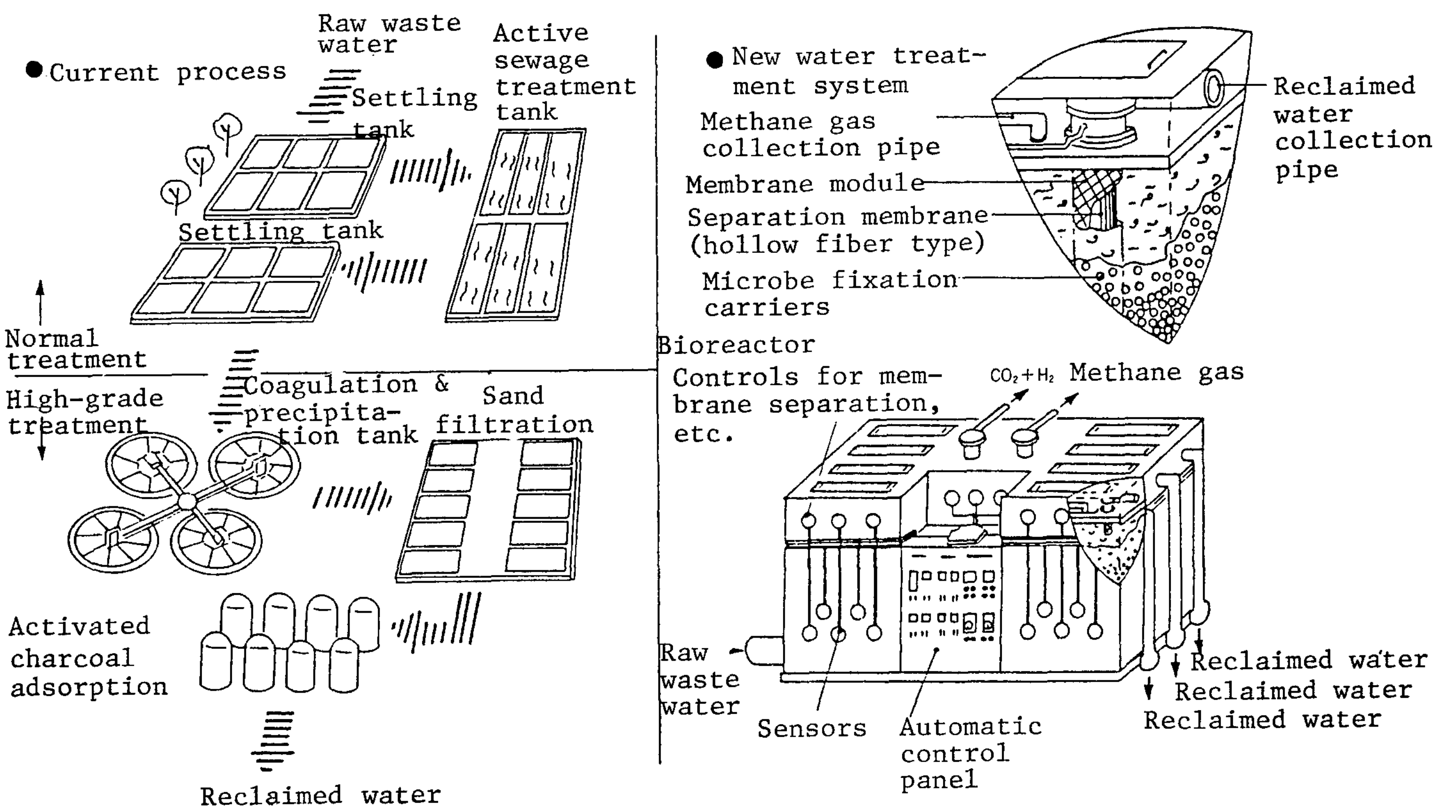



Figure 1. Comparison of Current Process and New Water Treatment System

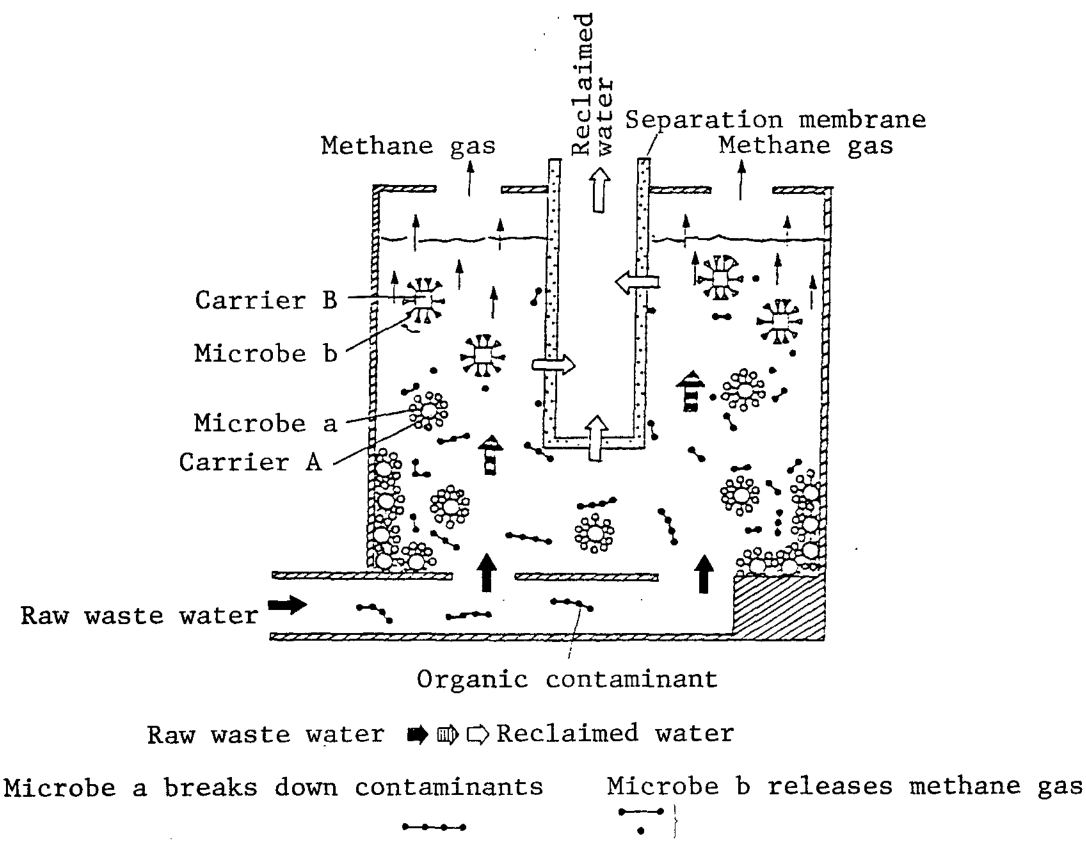



Figure 2. Water Treatment Using Bioreactor and Membrane Separation

R&D Schedule

| | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|
| Microbe R&D | Development of selection, cultivation and activation technology | | | | Confirmation of selection, cultivation and activation technology | |
| Membrane material R&D | Development of high-grade membrane | | | | Confirmation of high-grade membrane development technology | |
| Water treatment reactor R&D | | Element research | Basic experimentation | | | |
| Methane fermentation membrane module development | | Element research | Basic experimentation | | | |
| New methane fermentation bioreactor development | | Element research | Basic experimentation | | | |
| Methane fermentation instrumentation system development | | Element research | Basic experimentation | | | |
| Overall survey research on methane fermentation | | | | | | |
| (1) Total system research | Total plan formulation | Survey of technological trends | Concept design | Detailed design & fabrication | Operational testing and evaluation | |
| (2) Support survey research | | Survey research | | | Survey research | |
| | | | | Interim evaluation | | Overall evaluation |

Interoperable Database System

R&D period FY 1985-91
R&D cost approximately ¥15 billion

Background and Purpose of R&D

It is thought that activity in a variety of fields in the society of the 1990's will be increasingly dependent on voluminous and varied information. For that reason, the extension of databases that store economic data, technical data and other kinds of data in computers can be expected.

If, however, that extension follows the lines of present technology, there will still be such inconveniences as that there will be no mutual operation of databases on different kinds of computers, that users will have to use terminal equipment attached to the various databases, and that the data will have to be handled as text or limited graphic forms.

The goal of this project is to develop technology to prepare an infrastructure for a highly information-oriented society by enabling users to easily access database systems from their own information equipment, and to allow their use of multi-media information including text, graphics and images. Realization of this system technology will make the following possible:

(1) To assure interoperability of information equipment and information systems, to expand the range of users' equipment choices, and to unnecessary duplication of investment;

(2) To play a leading role in the development of future information systems, to raise the level of technology and to lighten the immense burden of system development for the country as a whole;

(3) To contribute to the spread of world information use, through input to international standards, for example.

Outline of R&D

The purpose of this project is to assure the interoperability of computers, and to establish the technology necessary to build a highly reliable, distributed database system that can handle multi-media information.

The following technology is being developed for that purpose.

(1) Distributed Database System Technology

The development of technology that will enable distributed database systems to be used just as though they were a single database system, and technology for the optimum distribution and control of databases when a new distributed database system is built.

(2) Multimedia Technology

The development of technology for the realization of a high-level information system that can use multimedia information, including text, graphics, images and sound, without awareness of differences in mode of expression or memory media.

(3) High-Reliability Technology

The development of technology that will keep small system abnormalities from having much effect on the large-scale system as a whole, of technology for early recovery when abnormalities develop, of technology to keep data safe, and so on.

(4) Interoperable Network System Technology

The development of technology for connecting with and operating with information equipment and systems that follow the "open systems interconnection" (OSI) of the International Organization for Standardization (ISO).

(5) Advanced Database System for Power Stations

The development of a highly reliable, advanced database system for power stations capable of efficient, distributed processing, through a high-speed, advanced-function network, of the multimedia data (including graphics and images) required in power stations.

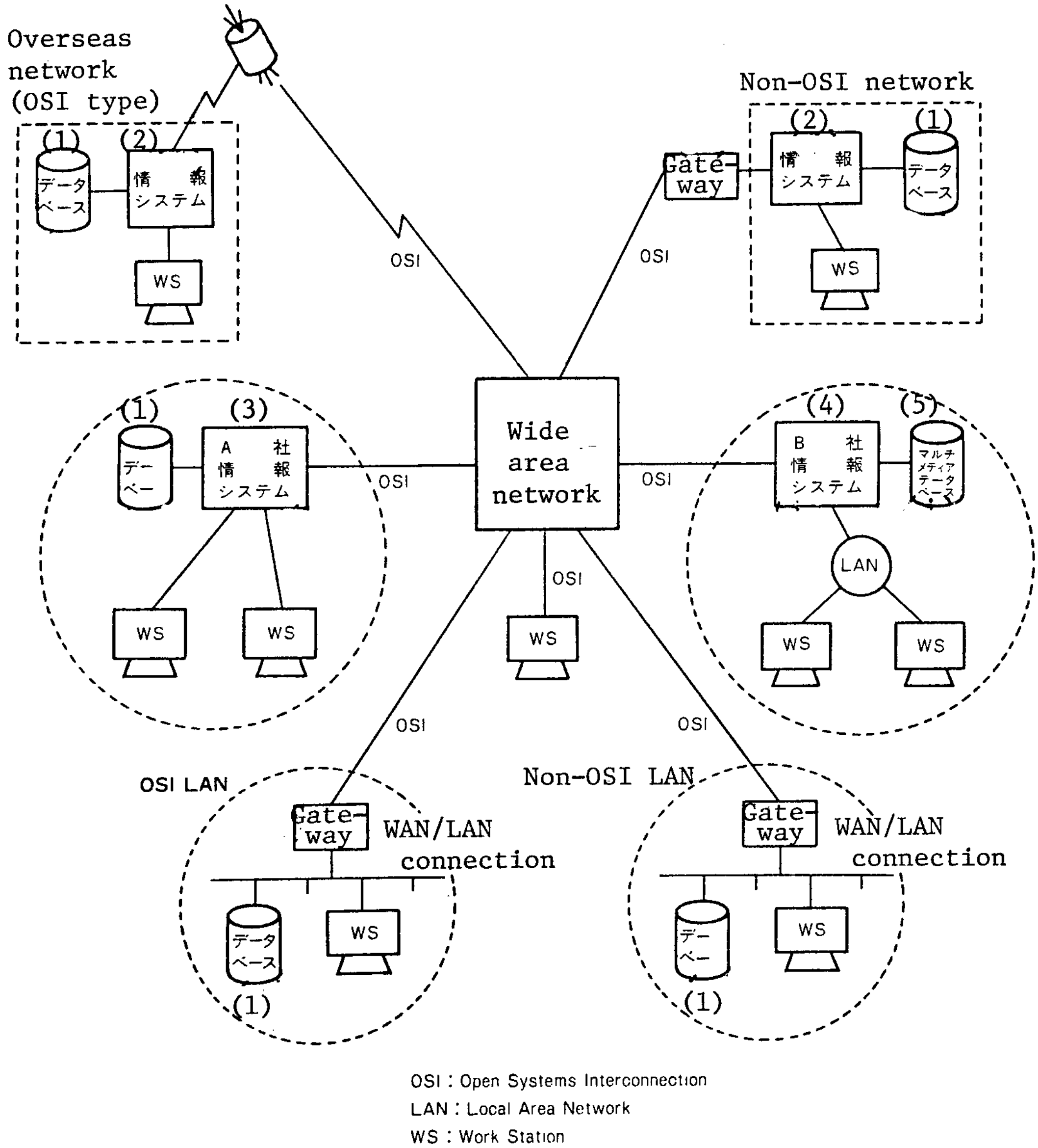



Figure 1. Future Interoperable Network System

Key:
1. Database
2. Information system
3. Company A information system
4. Company B information system
5. Multimedia database

R&D Schedule

| | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|---|---|
| 1. Distributed database system technology R&D | Basic technology development | | | First stage system operation and interim evaluation | System technology development | | Final stage system construction and final evaluation |
| | Survey research | Basic method research | Basic method design | | Expansion method research | Expansion method design | |
| 2. Multimedia technology R&D | Basic technology development | | | | System technology development | | |
| | Survey research | Basic method research | Basic method design | | Expansion method research | Expansion method design | |
| 3. High-reliability technology R&D | Basic technology development | | | | System technology development | | |
| | Survey research | Basic method research | Basic method design | | Expansion method research | Expansion method design | |
| 4. Interoperable network system technology R&D | Basic technology development | | | | System technology development | | |
| | Survey research | Basic method research | Basic method design | | Expansion method research | Expansion method design | |
| Power plant high-performance database system development | | | | Preliminary design | Block design | Detailed design and fabrication | Demonstration testing & evaluation |

Advanced Material Processing and Machining System

R&D period FY 1986-93
R&D cost approximately ¥15 million

Background and Purpose of R&D

Advanced technology industries like energy, precision machinery, electronics and aerospace will have a central presence in Japan's industry, and as such, their growth is anticipated.

These advanced technology industries have responded to higher requirements by doing advanced and complex machining and processing of various materials, making parts with optimal functions, and assembling them into systems. But with progress in technology, materials specifications are becoming more advanced and hard-to-machine materials are emerging, and with progress in electronics technology, the precision of machine parts is becoming harder to achieve; it is becoming difficult to upgrade the performance of the machinery needed by the advanced technology industry.

On the other hand, considered in terms of the seeds of precision processing technology, in recent years there has been remarkable progress in the application of excimer lasers and ion beams to precision processing technology. That, together with the use of new machining equipment made with new materials and parts that have been precision machined with laser and ion beams, has given rise to the possibility of achieving ultra-precision processing using methods that are radically different from those of the past.

This project is responding to such a situation by doing R&D on machining and processing of hitherto impossible ultra-precision, and on surface processing with the unprecedented use of laser and ion beams, in order to make possible the precision processing required by the advanced technology industry.

This R&D has the goal of developing very advanced processing equipment including 1) high-output excimer lasers, 2) high density ion beams and 3) advanced material machining and processing equipment.

Another goal is the development of ultra-precision processing technology using that equipment, and of measuring and evaluation technology to support it.

Outline of R&D

R&D for the advanced materials machining and processing system is being done on surface processing with the unprecedented use of laser and ion beams, and on machining and processing of hitherto impossible super-precision. The specific content of R&D is as follows.

1. R&D on Very Advanced Processing Equipment Technology

(1) R&D on High-Output Excimer Laser Technology

Development of technology regarding higher power output, more rapid repetition and greater longevity is being done in order to develop a high-output excimer laser capable of processing a surface by directly illuminating the surface of the material with ultraviolet light that causes a chemical reaction and forms a different substance.

(2) Research on High Density Ion Beams

Efforts are under way to develop a high current ion source, diversify ion types, expand the energy range and improve longevity, in order to develop highly concentrated ion beams that can implant various elements into the material and create a new material with organization that changes in accordance with the depth from the surface.

(3) Advanced Material Machining and Processing Equipment

Equipment is being developed that does high-efficiency processing with precision two orders of magnitude greater than conventional equipment, by cutting and machining complex, three-dimensional parts, such as nanometer machining of photochemical elements. That will be done by adopting a machine carriage with a rigid structure using new materials, and electromagnetic feed mechanism that uses electric and magnetic deflection and an in-process sensing control method (in which measurement and control are simultaneous with machining).

2. R&D on Very Advanced Processing Technology

Technology is being developed for micromachining of surfaces by forming highly functional layers using the phenomenon of activation of atoms and molecules by exciting the surface of the material with an excimer laser or ion beam, as is technology to rapidly improve the uniformity of the surface layer, to a depth of several microns, by exposing the material to a high-current ion beam or to an excimer laser.

3. R&D on Support Technology

Technology is being developed for ultra-precision measuring and evaluation that is capable of using laser beams, ion beams, electron beams and X-rays for rapid, non-contact measurement of the size, shape, roughness and organization of advanced machinings.

4. R&D on Total System

System concept design for construction of an advanced material machining and processing system will be done, followed by overall testing of the system.

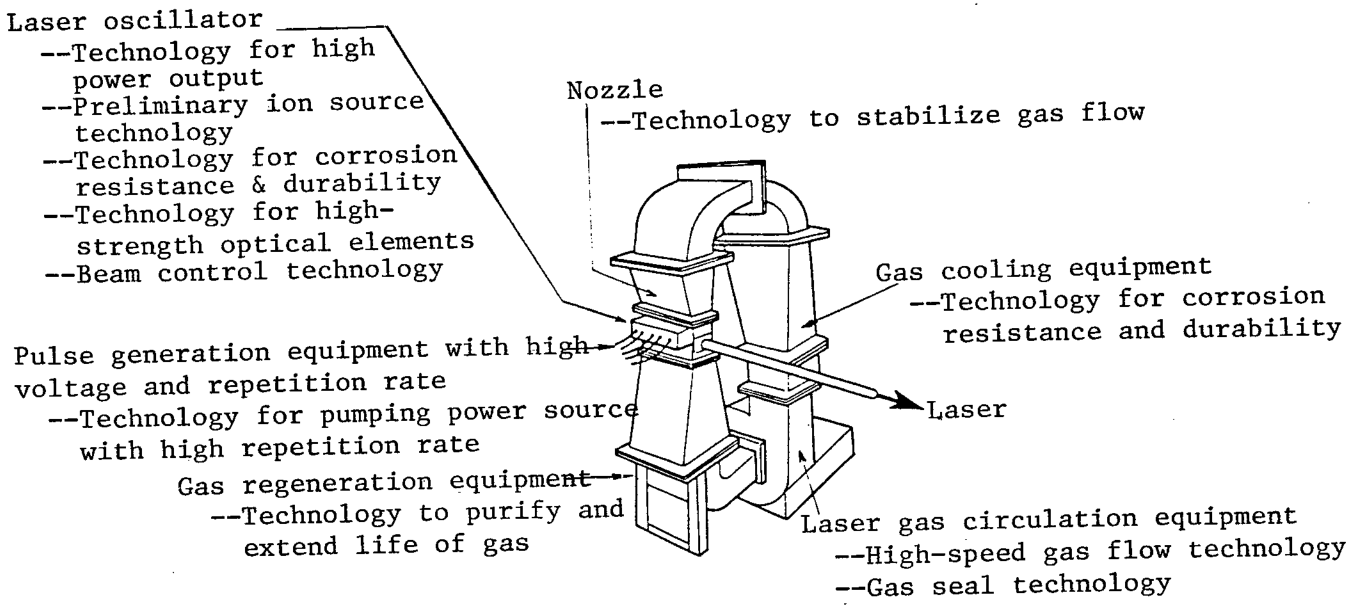



Figure 1. High-Output Excimer Laser

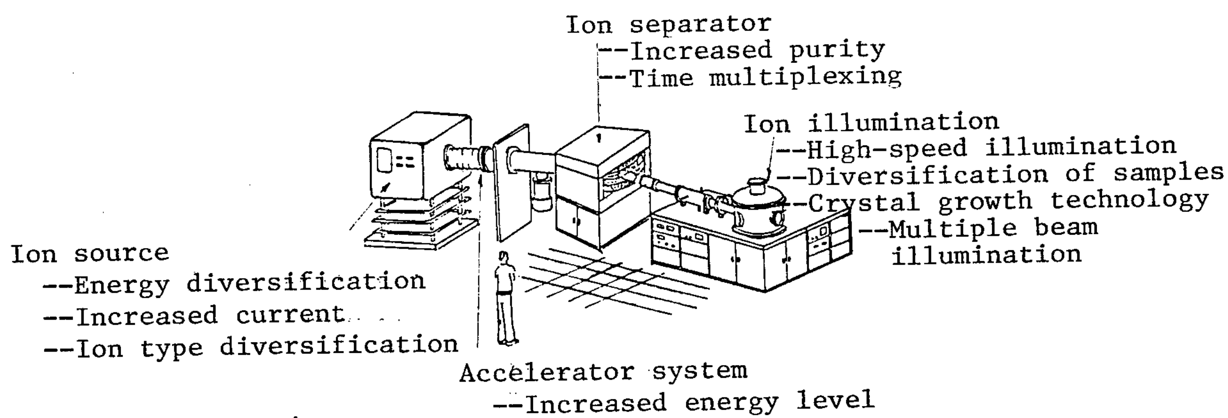
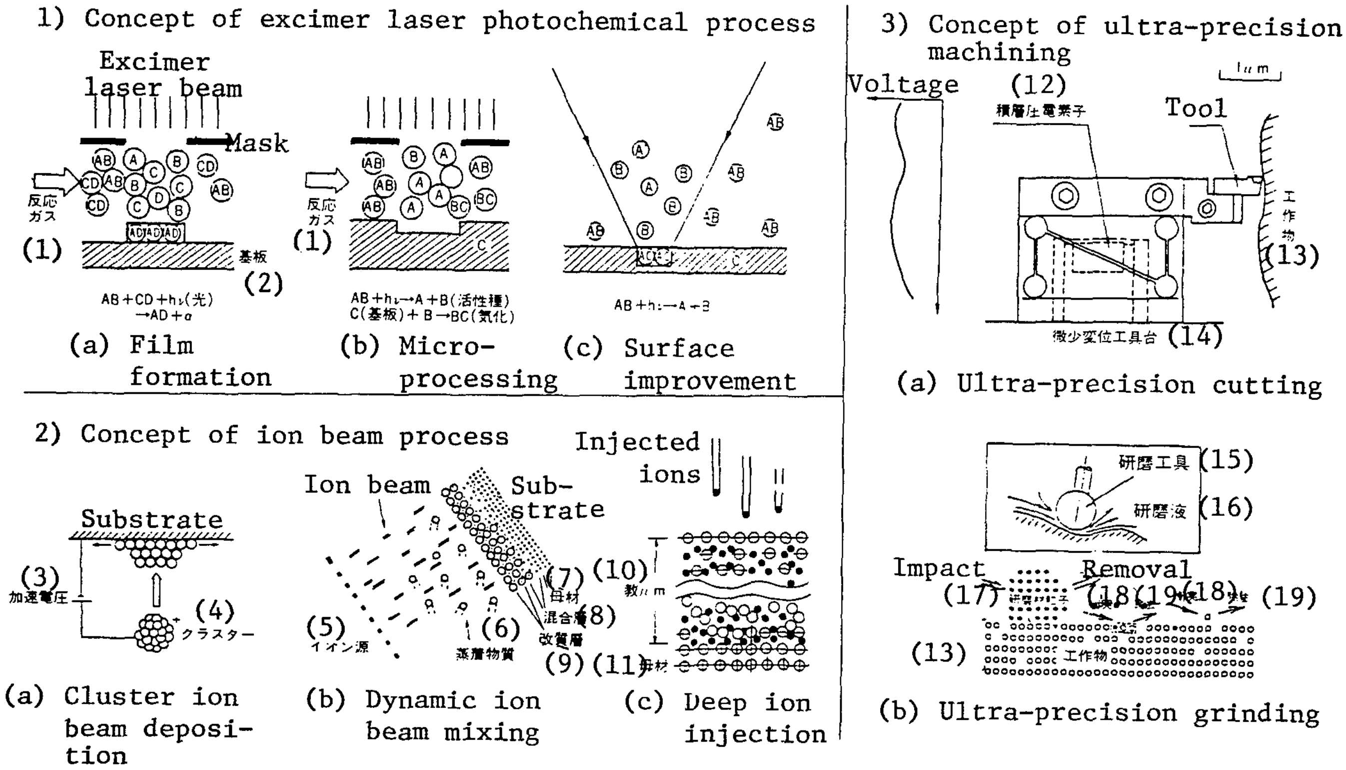



Figure 2. High Density Ion Beam




Key:

1. Reaction gases
2. Substrate
3. Acceleration voltage
4. Cluster
5. Ion source
6. Deposition material
7. Base material
8. Mixed layer
9. Improved layer
10. Several microns
11. Base material
12. Stacked piezoelectric element
13. Workpiece
14. Micropositioned tool stage
15. Grinding tool
16. Grinding fluid
17. Particle of grinding agent
18. Impact
19. Removal

R&D Schedule

| | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | |
|---|---|---|---|---|---|---|---|---|---|
| I. Advanced processing and machining equipment technology<br>1. High-output excimer laser technology research<br>2. High-density ion beam technology research<br>3. Ultra-precision machining technology research | Survey | Element technology development | | Fabrication, testing | Interim evaluation | Production | Improvement | Testing | Overall evaluation |
| II. Very advanced processing technology | Survey | Element technology development | | Optimization tests | Interim evaluation | Fabrication, testing | Improvement | Testing | Overall evaluation |
| III. Support technology | Survey | Basic design | | | Interim evaluation | Detailed design | Production | Testing | Overall evaluation |
| IV. Total system | Overall plan formulation | Concept design | | | Interim evaluation | | Overall testing | | Overall evaluation |

Fine Chemicals From Marine Organisms

R&D period FY 1988-96
R&D cost approximately ¥15 billion

Background and Purpose of R&D

Japan has the world's sixth largest economic zone within its 200 nautical mile limit. The use of biotechnology to promote development of marine organisms can be considered an international obligation for Japan as it enters the 21st century.

Biotechnology is currently focused primarily on land resources, which are relatively easily approached. However, highly diverse biological resources are much more plentiful in the sea, which is the source of life on the earth, than on land. To gain an understanding of that life system and to produce and industrialize fine chemicals would greatly open up the frontier of biotechnology.

Compared with the land, the environment for cultivating marine resources is harsh and diverse, in terms of pressure, temperature and the availability of oxygen and light; consequently, many difficulties are involved in sampling, preserving and growing such resources. Land-based biotechnology is not directly applicable; it will be necessary to establish saline cultivation methods, recombinant genetic technology, cell fusion technology and so on.

In order to deal with such a situation, this R&D project will promote the use of marine organisms, research and develop a new biotechnology based on those diverse and abundant resources, and thus establish technology for production of a variety of fine chemicals.

Outline of R&D

With biotechnology, we will make efficient use of marine organisms, and will develop technology to produce fine chemicals, including materials to coat marine structures, pigments, dyes and moisturizers.

Specifically, R&D will be done in the following categories.

(1) Basic Technology Using Marine Organisms

Technology will be established for collecting, separating, cultivating and preserving marine organisms, and for fostering and improving stocks.

(2) Technology for Seeking and Refining Useful Substances

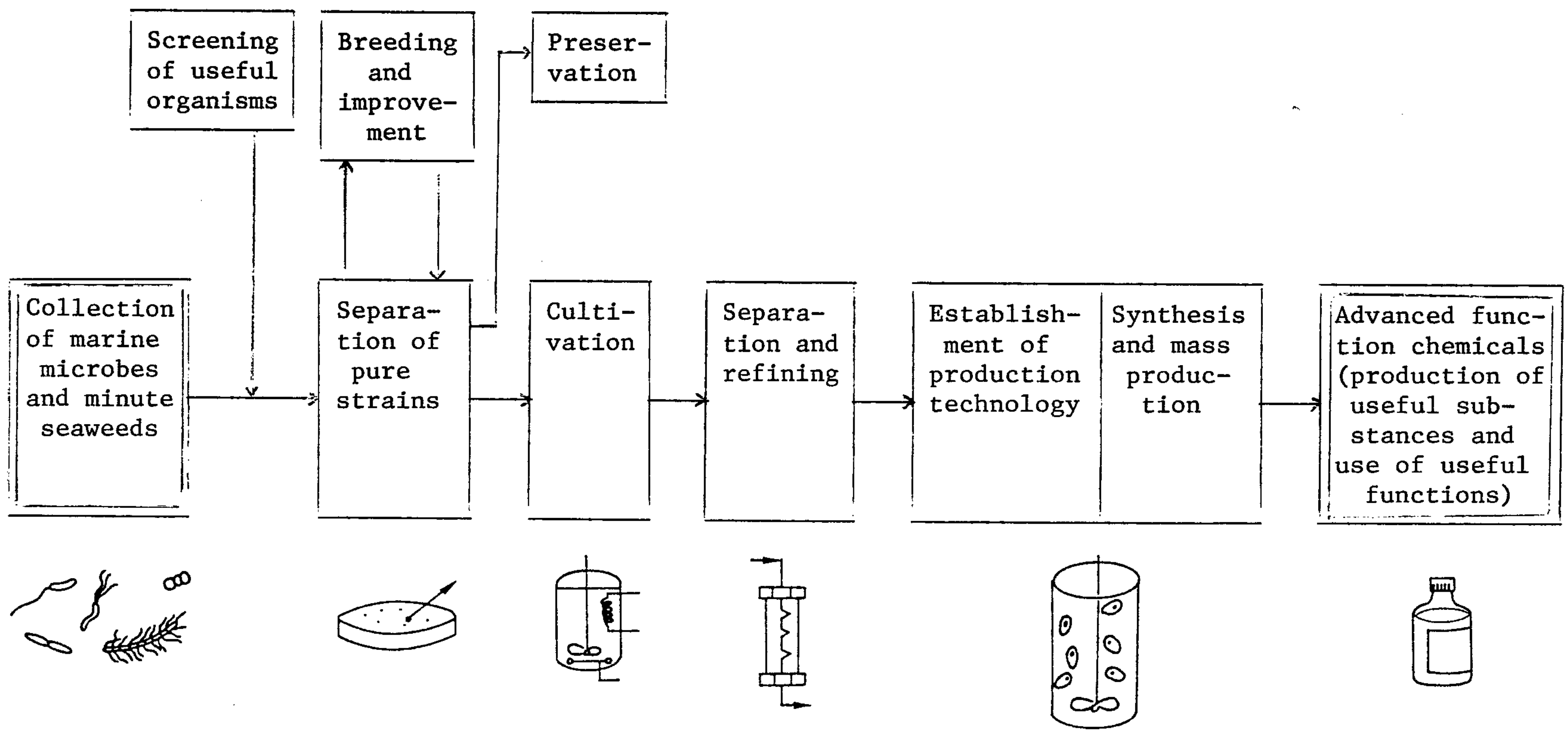
Technology for determining the utility of fine chemicals produced from marine organisms will be established, along with technology for extraction, separation and refining.

(3) Technology for Finding and Explaining Useful Biological Functions

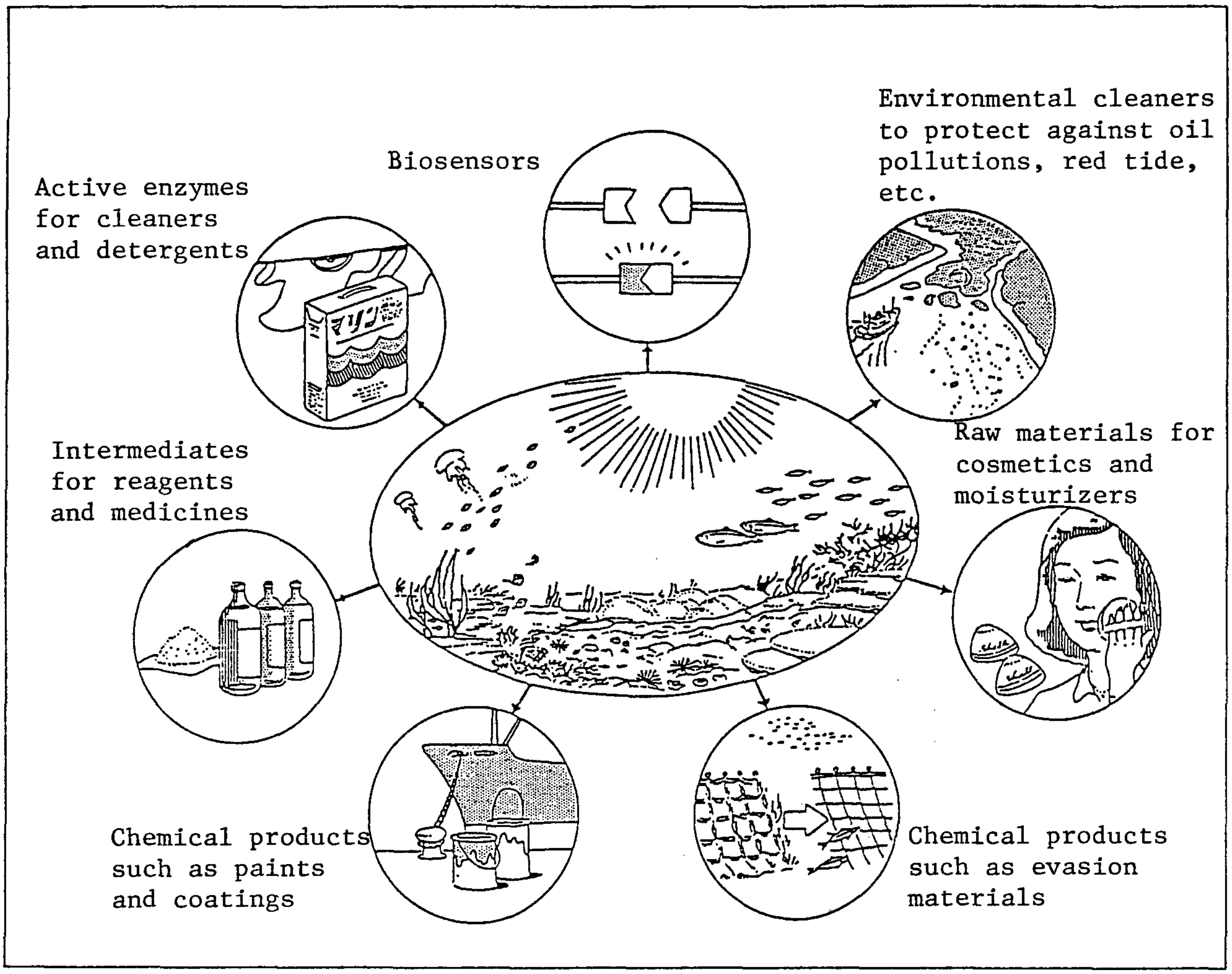
Technology will be established for finding, explaining, measuring and evaluating useful biological functions, in order to make use of the functions that marine organisms possess.

(4) Support Technology

Technology will be established for major equipment including the Aquatron and collection equipment, and an open-use database will be prepared.




Structure of R&D




Results Anticipated From Methods for Production of Fine Chemicals (using marine organisms)

## R&D Schedule

| | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|
| I. Basic technology using marine organisms | | | | | | Intermediate evaluation | | | Final evaluation |
| (1) Collection, separation, cultivation and preservation technology | Preliminary survey | Preliminary research | Element technology | | | | | | |
| (2) Technology for fostering and improving stocks | Preliminary survey | Preliminary research | Element technology | | | | | | |
| II. Technology for seeking and refining useful substances | | | | | | | Intense research, establishment of technology | | |
| (1) Technology for finding useful substances | Preliminary survey | Preliminary research | Element technology | | | | | | |
| (2) Technology for refining useful substances | Preliminary survey | Preliminary research | Element technology | | | | | | |
| III. Technology for finding and explaining useful biological functions | | | | | | | Intense research, establishment of technology | | |
| (1) Technology to find and explain useful biological functions | Preliminary survey | Preliminary research | Element technology | | | | | | |
| (2) Technology to measure and evaluate useful biological functions | Preliminary survey | Preliminary research | Element technology | | | | | | |
| IV. Support technology | | | | | | | | | |
| (1) Technology for major equipment | | Concept formulation | Basic specification design and fabrication | | | | Detailed design, fabrication, operation, evaluation | | |
| (2) Information processing technology etc. | | Concept formulation | Basic specification design | | | | Database formation | | |

Supersonic Transport Propulsion System

R&D period FY 1989-indefinite
R&D cost not determined

Background and Purpose of R&D

With the approach of the 21st century there has been an earnest desire for realization of a supersonic air transport that could connect the Pacific region with the countries of Europe and the United States in a matter of hours. This would make it possible by the beginning of the first decade of that century to fly from Tokyo to New York in 3 to 5 hours.

One important task that holds the key to realization of this supersonic transport will be the propulsion system. For that reason, it has been decided to conduct R&D on a "Supersonic Transport Propulsion System."

Outline of R&D

We will develop a combined cycle engine that integrates, to a high degree, the new "ramjet" and "high-performance turbojet" propulsion technologies, so as to achieve high reliability and good fuel consumption over a wide range from low speeds to Mach 5.

Specifically, R&D will be done in the following categories.

(1) Ramjet R&D

A ramjet will be developed with high efficiency and high power capable of stable flight at Mach 5.

(2) High-Performance Turbojet R&D

A high-efficiency, high-output turbojet will be developed with a small diameter, to be the core of the combined cycle engine.

(3) Instrumentation and Control System R&D

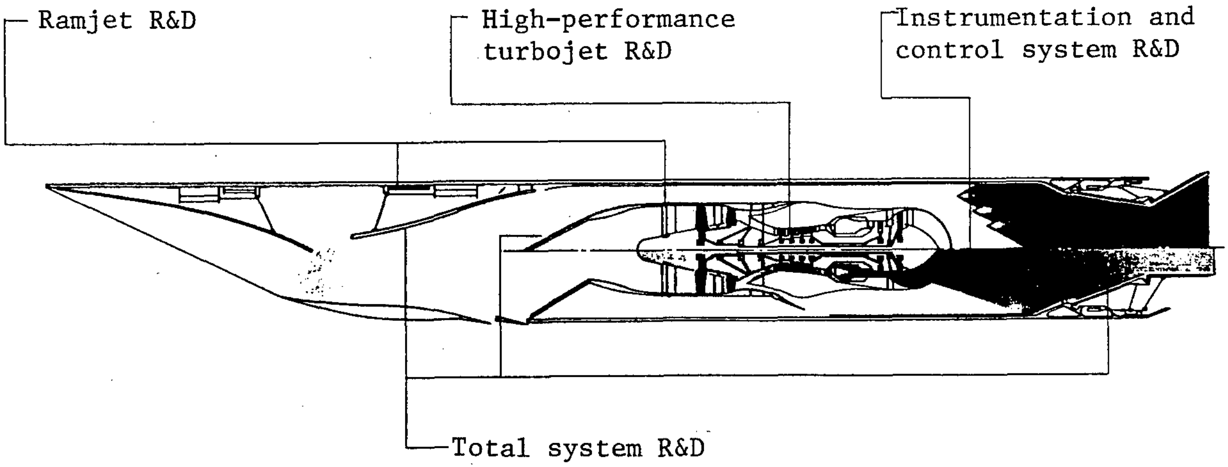
A system will be developed to measure and control the engine as a whole.

(4) Total System R&D

The optimum combination of subsystems will be established, and variable mechanisms will be developed.

(5) Prototype System Fabrication

A prototype of the combined cycle engine will be fabricated, its capabilities will be tested, and the needed data will be accumulated and evaluated.




Concept Drawing of Combined Cycle Engine

Technology for Development of Space Deep Underground

R&D period FY 1989-indefinite
R&D cost not determined

Background and Purpose of R&D

Japan has about 120 million citizens living on 370,000 square kilometers of territory, and the majority have to reside on the habitable portion of that territory, which is only 7 percent of the total. The extreme concentration of population and functions in urban zones, particularly in recent years, has brought about a sharp rise in land prices and high density utilization of land. To resolve these problems, it is necessary to promote the expansion of space resources by making use of space underground.

Depending upon the field for which this underground space is used, it will also be possible to take advantage of such fundamental characteristics as thermal insulation, air-tightness and seismic stability. However, the technology for utilization of urban space is not yet established; creating such space using existing technology would involve economic difficulties. Consequently, to promote the use of underground space it will be necessary to establish underground space utilization technology. To solve the various problems of urban areas it will be necessary to prepare an urban social foundation that includes cultural and commercial facilities, an energy infrastructure (for the production, storage and distribution of energy), the recycling of resources (treatment of waste water and other industrial wastes), and distribution of materials. It will be necessary to bring about a more abundant life for the citizens. For that reason, it has been decided to conduct R&D on "Technology for Development of Space Deep Underground."

Outline of R&D

In order to encourage the use of industrial and energy facilities deep (at least 50 meters) underground, we will develop the technology necessary to build and use a dome-shaped space with a floor 50 meters in diameter and a height of 30 meters.

Specifically, R&D will be done in the following categories.

(1) R&D on High-Precision Technology for Evaluation of Underground Structures

Using the principles of the CT scanners now in use in the field of medicine, we will develop high energy oscillators, receivers and technology for data analysis necessary for cross-hole tomography using elastic waves and electromagnetic waves.

(2) R&D on Technology for Construction of Space Deep Underground

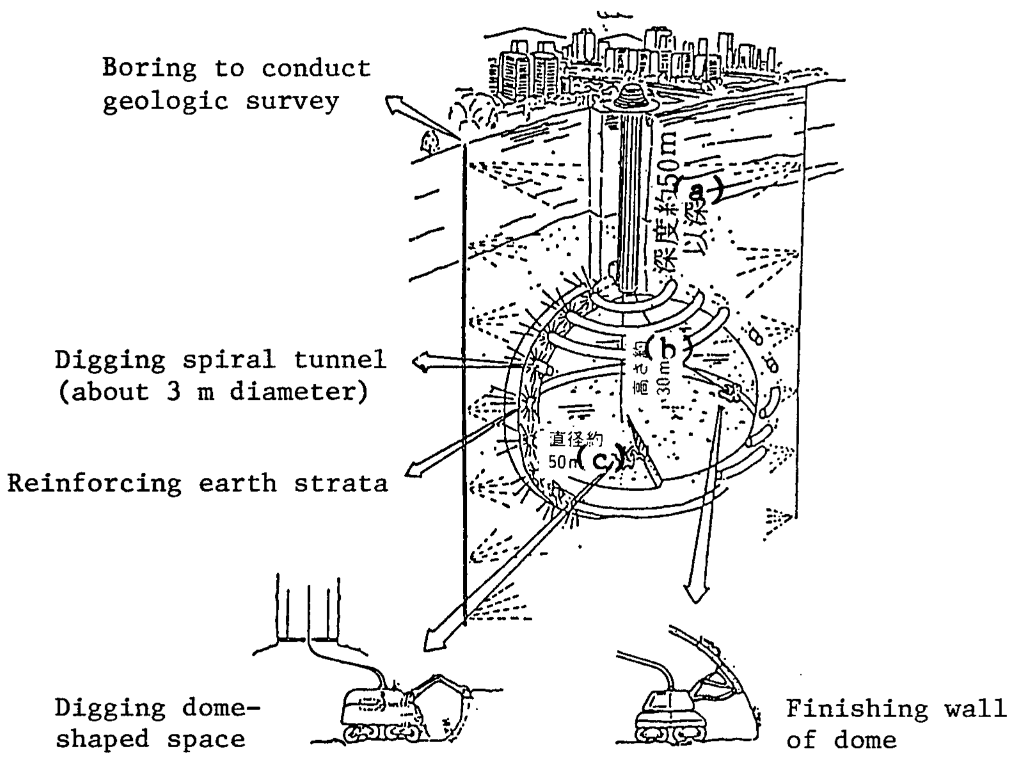
In order to build dome-shaped spaces deep underground, we will develop such things as equipment to bore tight curves in soft rock, submerged automatic cutting equipment that can work under water, and submerged automatic lining equipment.

(3) R&D on Technology for Disaster Prevention and Environmental Control Deep Underground

In order to overcome the disadvantages of underground spaces and to assure greater safety and convenience, we will develop environmental control technology for use in spaces deep underground, and security technology capable of responding to disasters.

(4) R&D on the Total System

To make a total system of the element technology listed above, we will conduct overall demonstration tests by developing small, underground dome-shaped spaces.




Development Concept Drawing

Key:
- a. Depth at least 50 m
- b. Height about 30 m
- c. Diameter about 50 m

III. Outline of Completed Projects and Their Results

R&D on 17 projects has been completed from the inception of the system in 1966 through the end of FY 1988. An outline of these projects and their results is introduced below.

(1) Very High-Performance Computers

R&D period FY 1966-71
R&D cost about ¥10.1 billion

Early in the 1970's, as the world's electronic equipment was shifting from the third generation (IC's) to generation 3.5 (LSI's), this project undertook R&D with the purpose of challenging the advanced technology of IBM and others, and of producing domestically computers with world-class performance.

This project developed not just the computer itself, but also the software and I/O devices to use it effectively, as well as semiconductor devices and various types of memory for high-performance hardware.

One result of the project is the use of a number of large, domestically produced computers. But by greatly raising the level of semiconductor and computer technology, the project also succeeded in shrinking the technology gap that separated Japan from the advanced countries of Europe and the United States, and in making a great contribution to the technological foundation for future development of the Japanese electronics industry.

(2) Desulfurization Technology

R&D period FY 1966-71
R&D cost about ¥2.7 billion

With the increased consumption of heavy oil, there has been greater damage to society from the release of the sulfur content of heavy oil into the atmosphere as sulfur dioxide. With that background, this project performed R&D on technology to remove sulfur dioxide from combustion exhaust gases (exhaust desulfurization) and on technology to directly remove sulfur from heavy oil (direct desulfurization of heavy oil).

The exhaust desulfurization portion took up the activated manganese oxide and activated carbon dry methods, and conducted operational research in a pilot plant. In the direct desulfurization portion, after various portions were studied, a test plant using the suspension bed method was constructed and operational research was conducted.

The results put to use in large, conventional power plants. Moreover, when society's attention came to be focused on the problem of pollution, the fact that the government had taken the lead in development of technology greatly encouraged the development of desulfurization technology and use of desulfurization equipment by private enterprises.

(3) New Manufacturing Methods for Olefins

R&D period FY 1967-72
R&D cost about ¥1.2 billion

In the latter half of the 1960's, Japan's petrochemical industry was undergoing rapid growth, but it depended almost entirely on naphtha, a light petroleum distillate, as a raw material, and the prospects for a stable supply of naphtha could not be called bright. With that situation as the background, this project conducted R&D on technology to manufacture olefins (the general category that includes ethylene, propylene, etc.), which are basic chemical products, by direct cracking of crude oil, the supply of which could be expected to be stable both in terms of quantity and low cost. The project took up the "Cokes Thermal Medium Method," an independent Japanese technology, and confirmed the technical feasibility through operational research in a test plant that processed 5 tons of raw material per day.

The results of this project were taken directly into the project for "production of olefins from heavy oil" as its technological basis.

(4) Remotely Operated Deep Sea Oil Drilling Equipment

R&D period FY 1970-75
R&D cost about ¥4.5 billion

As prospecting for petroleum tended to move from the mainland, across the coast to the continental shelf, this project carried out R&D on new types of oil-drilling equipment that could be used deep in the ocean.

The project achieved its original objective of establishing a method and developing mechanisms for seabed petroleum drilling at depths of 200 to 250 m, in which the dynamic force is located on the surface, and most of the drilling equipment is set up on the seabed and operated remotely.

The results of this project were taken directly into the "Seabed Petroleum Production System" project, as its technological basis.

(5) Desalination and Use of Byproducts

R&D period FY 1969-76
R&D cost about ¥6.7 billion

With the shortage of water becoming a serious social problem in metropolitan Tokyo and other large urban areas, R&D was done on technology to produce large volumes of fresh water at a low cost using sea water as a raw material, and on technology to extract sodium chloride, potassium chloride and so on as byproducts.

There are many methods for desalination of sea water. This project used a multistage, flash evaporation method because it was capable of producing large volumes cheaply. It included research in a test plant (producing 3,000 cubic meters per day), and partial fabrication and operation research on a large-scale desalination facility (100,000 cubic meters per day).

The fruits of the project have been put to use on remote islands and in atomic power plants, and a number of plants have been exported to Saudi Arabia and other Middle Eastern countries.

(6) Electric Automobile

R&D period FY 1971-76
R&D cost about ¥5.7 billion

Because automotive pollution, including automobile noises and pollution of the air by automobile exhaust gases, had become a social problem as became overcrowded, R&D was done on an electric automobile that would not emit exhaust gases, that would produce markedly less noise, and that was operated simply and could be automated easily.

The project developed world-class technology for an electric car with an independent battery that could travel about 250 km on a charge (about 100 km

had been normal) and an electric car with a hybrid battery that could travel about 450 km.

The results have been put to practical use in the streets of Kobe and Kyoto, and the large power transistors developed as element technology are in use in such equipment as forklifts.

(7) Automobile Management Technology

R&D period FY 1973-78
R&D cost about ¥7.3 billion [passage omitted]

(8) Pattern Processing System

R&D period FY 1971-80
R&D cost about ¥21.9 billion

With the progress of the information-oriented society, there was a need for information processing systems capable of direct input and processing of textual, graphic, object and sound patterns that could not be acquired by current computers. Against that background, R&D was done on an information processing system with a goal of practical application during the 1980's.

In this project, R&D was done on element technology including input and conversion technology needed for pattern information processing, new materials for parts, functional devices, software, operating systems and so on. Technology was developed at the world's highest level, and ultimately an overall system prototype that combined that technology was created and operated.

As accomplishments of the project, such things as optical character reading and graphic processing equipment (developed as memory devices and element technology) is in wide use. Moreover, the project raised the level of technology in the field of pattern information processing sharply, and contributed greatly to the expansion of the information processing field from numbers to text, graphics, sound and so on.

(9) Direct Steel-Making Using High-Temperature Reducing Gas

R&D period FY 1973-80
R&D cost about ¥13.7 billion

To escape from the pollution problems that accompany current steel-making methods, and to escape from dependence on coking coal, R&D was done on technology for direct use in steel-making of the thermal energy of multipurpose, high-temperature gas furnaces expected to be developed in the near future.

This project developed such things as a high-temperature heat exchanger to transfer heat to the secondary helium loop from the primary helium loop that emerges from the gas furnace at about 1,000°C, heat-resistant alloys that

can withstand use at 1,000°C for long periods, high-temperature refractory materials, reducing gas production equipment to produce reducing gas cheaply from low-pressure petroleum residues. It also established the technology needed for a direct steel-making pilot plant to connect to the experimental, multipurpose high-temperature gas furnace (50 MW thermal output) which was the original objective.

Now, because the construction design for the experimental, multipurpose high-temperature gas furnace has been delayed, the direct steel-making pilot plant has not been constructed yet, but future progress is anticipated.

(10) Production of Olefins From Heavy Oil

R&D period FY 1975-81
R&D cost about ¥13.8 billion

At present, Japan's petrochemical industry relies completely on naphtha as a raw material; diversification of raw materials has become a serious problem. For that reason, this project conducted R&D on technology to manufacture olefins, which are basic chemical products, from heavy oils including low-pressure petroleum residues ("asphalt").

This project started with the technology that resulted from the project on a "new olefin production method," which used crude oil as a raw material, then built a large pilot plant (processing 120 tons of raw material per day) and kept it in continuous operation for a long period (1,000 hours).

The accomplishments of this project have been noted by other countries, because they can be applied to such things as oil sand.

(11) Jet Aircraft Engine

First stage: R&D period FY 1971-75
R&D cost about ¥13.8 billion

Second stage: R&D period FY 1976-81
R&D cost about ¥12.9 billion

Because jet aircraft engines require a very high level of technology, Japan has not had independent technology to produce them. For that reason, R&D was done on a fanjet engine with high efficiency and little pollution, to be used in civil aircraft.

The basic technology needed for jet engines was developed in the first stage of this project. In the second stage, safety, durability and reliability were further established, and a fanjet engine in the 5-ton propulsion class was developed.

One result of this project was the development of an engine to be mounted in the STOL (short takeoff and landing) aircraft being developed by the Science and Technology Agency. In addition, it contributed greatly to raising the

domestic level of technology by creating the opportunity to begin joint development of a jet engine by five countries (V2500).

(12) Energy Recycling Technology System

First stage: R&D period FY 1973-75
R&D cost about ¥1.3 billion

Second stage: R&D period FY 1976-82
R&D cost about ¥11.3 billion

From the perspective of resource conservation, energy conservation and solution of the problems associated with waste disposal, R&D was done on a new waste treatment system with the goals of effectively using resources and facilitating urban trash disposal. This system was to replace current waste-disposal methods like burning and landfill.

This project developed trash-disposal element technology in the first stage. In the second stage, a pilot plant combining the element technology was designed and constructed, and long-term operation research was conducted.

The results have already been put to use in cities and towns in Hokkaido and in Nagano, Kochi, Ehime and Oita prefectures. Moreover, the technology for selective crushing and separation equipment to separate trash has been provided to Austria; in this and other ways, the project has contributed greatly to promotion of the conversion of waste products into resources.

(13) High Performance Flexible Manufacturing System Complex Provided With Laser

R&D period FY 1977-84
R&D cost about ¥13.5 billion

The production of mechanical products has tended to move from the earlier mass-production mode to that of job-shop type production. With that background, R&D was done on a flexible manufacturing system that is integrated from the machining of component machine parts through product testing, which automatically manufactures products flexibly and quickly, and which uses lasers for the machining of metal.

During this project, a test plant was built and overall operation research was performed in the Mechanical Engineering Laboratory. The project succeeded in operating the world's largest commercial-scale carbon dioxide gas laser, with an output of 26.5 kW.

As a result, a portion of the laser-related technology was brought to a practical level. The project played a pioneering role in factory automation and the application of lasers to the machining of metals, and made a major contribution to the future development of new manufacturing systems. Moreover, a portion of the test plant was based on a combined research system,

and used for joint research by the Mechanical Engineering Laboratory, the Electrotechnical and nine private companies for research to bring technology to a practical level.

(14) Seabed Petroleum Production System

R&D period FY 1978-84
R&D cost about ¥18.2 billion

In recent years the focus of oil development has shifted from the land to the sea, and from shallow to deep waters. With that background, R&D was done to break through the limit (about 300 meters) on depths at which oil production is considered possible.

This project began with the technology that resulted from the project on "remotely operated deep sea oil drilling equipment" and developed methods to produce oil with the major production equipment located on the seabed; it carried out overall marine testing using a model oil field in waters 50 meters deep.

The result was a system with adequate safety, reliability, durability and economic operation; its future use for production of oil and natural gas is anticipated.

(15) Optical Measurement and Control System

R&D period FY 1979-85
R&D cost about ¥15.7 billion

Using optoelectronics, a combination of optical and electronic technology, R&D was done on optical measurement and control technology that would use light to enable, even in adverse environments including electromagnetic interference and flammable gases, the organic measurement and comprehensive monitoring and control of large volumes of images and other information generated within a given area such as an industrial zone or large plant.

During this project, a verification system for a petrochemical refinery was constructed. Operational research was conducted and the various kinds of element technology required for that were established.

The result was a system with adequate safety and reliability. It is anticipated that the system will be used for measurement and control in a variety of plants, that it will play a leading role in optoelectronic technology including the development of OEIC's, and that it will lead to new advances in the use of light.

(16) One-Carbon-Molecule Chemical Technology

R&D period FY 1980-86
R&D cost about ¥10.6 billion

In response to the unstable supply of petroleum and the trend toward heavier grades of oil, R&D was done on the use of coal, natural gas and tar sand as carbon resources to replace oil, with the goal of establishing new production technology to use such carbon resources to produce the basic chemicals that are indispensable to industry and daily life.

In order to use the synthetic gas (a mixture of hydrogen and carbon monoxide) obtained from coal and natural gas as a raw material for chemicals, this project established high-performance gas separation refining technology based on membrane separation to regulate the makeup of the synthetic gas. The project also developed new synthesis processes and catalysts for efficient production of basic chemicals such as ethylene glycol, ethanol, acetic acid and hydrocarbons (ethylene and propylene).

As a result of this project, some of the gas separation refining technology has already been put to use as a "high-efficiency hydrogen separation system." In addition, the chemical production technology using high-performance catalysts and membrane separation systems has attracted interest overseas.

(17) Observation System for Earth Resources Satellite

R&D period FY 1984-88
R&D cost about ¥13.8 billion

Japan, which has few energy or mineral resources, has depended on foreign countries for the majority of its resources; it has been necessary to carry out an active resource energy policy to assure a stable supply of these resources.

With that background, MITI and the Science and Technology Agency jointly established February 1992 as the target for launching Earth Resources Satellite 1 (ERS-1) to survey resources, and carried out R&D on an observation system for resource surveys, consisting of a data transmission system and synthetic aperture radar/optical sensors included in the satellite design.

The observation system undergoing this R&D enabled the mounting of synthetic aperture radar and optical sensors capable of high resolution in a satellite that is quite light in comparison with those that have been launched by foreign countries. The system has higher performance than the earth observation satellites of other countries, and is evaluated as having established technology for design and fabrication of the observation system for ERS-1. It is anticipated that there will be further improvements in methods to verify satellite data and image processing methods, and that remote sensing technology will be put to uses other than resource surveys, such as land use and environmental protection.

The Handling of Results

With regard to the results of R&D carried out through large-scale projects, the research results obtained by the laboratories of AIST and other government agencies are naturally the property of the government; development results obtained through commissioned research by private companies (including patents and other industrial property rights, and know-how designated by the AIST Director General) are also the property of the government. Noteworthy patents have been obtained for electronic equipment technology including LSI and IC memories, new high-capacity batteries and seawater desalination equipment. These results have steadily built up to 3,483 cases of domestic industrial rights, 197 cases of foreign industrial rights (extended to the government) including applications, and 7,298 know-how designations.

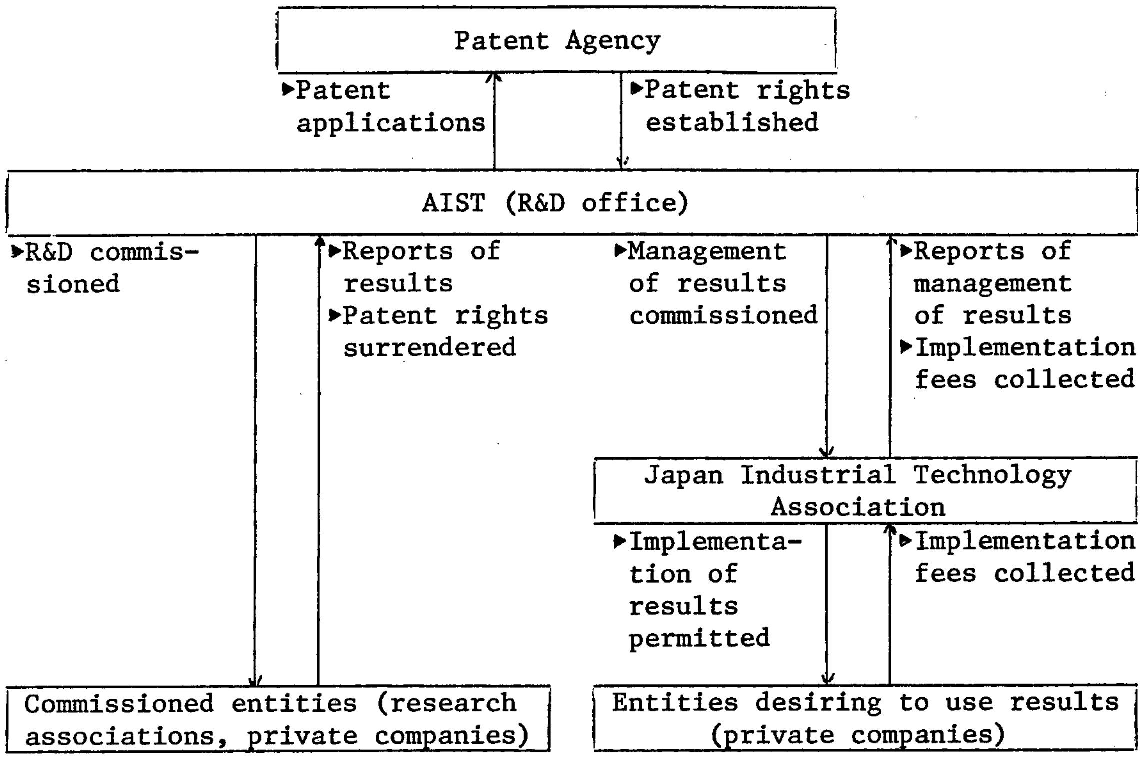
The use of R&D results is permitted on the conditions that the planned implementation of the results is in accordance with industrial policy or with public welfare, and that the applicant has the technical and economic capability to implement the results.

The fee for implementing the results is in accordance with usual schedule for use of government patents. So that the research results from AIST and national laboratories and the results of commissioned R&D done by the private sector can be diffused widely to companies in Japan and abroad, AIST is actively promoting distribution through the Japan Industrial Technology Association, established in 1969. It provides funds to that organization, and consults with it as needed regarding such things as desires to approve implementation.

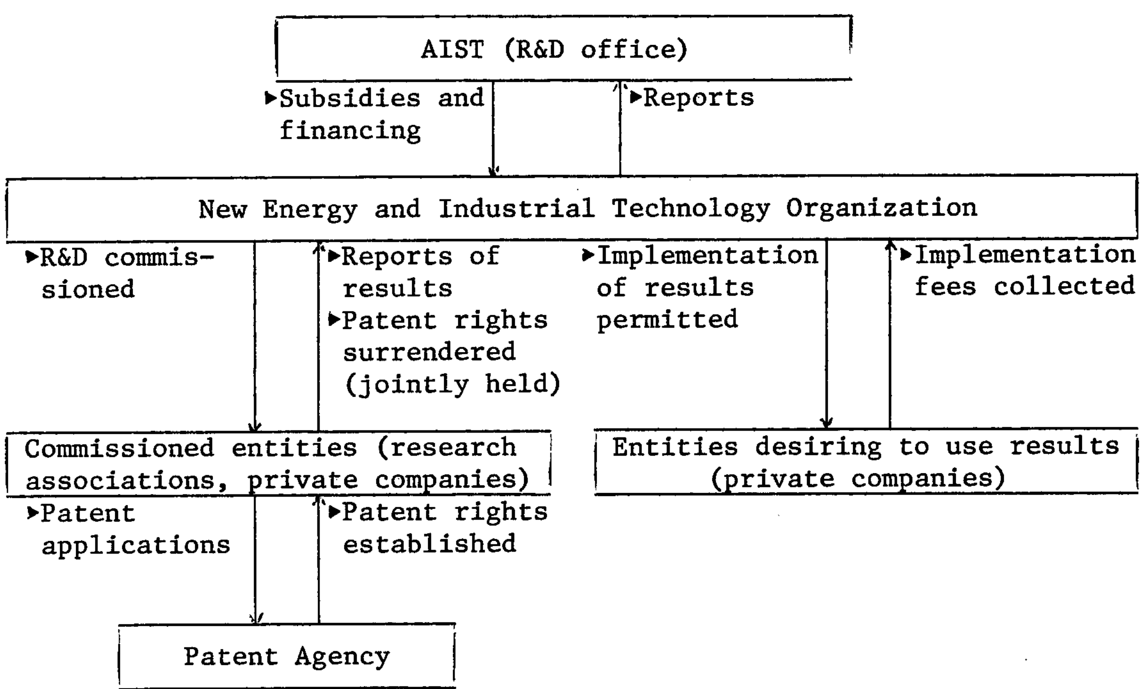
Now, it was decided that, beginning in the second half of 1988, commissioned R&D would be commissioned through the New Energy and Industrial Technology Development Organization, in order to implement R&D while making greater use of the R&D capabilities of the private sector. Research results thus obtained are jointly owned by the New Energy and Industrial Technology Development Organization and the private companies commissioned to do the R&D.

| (Payment required) ← | | → (No payment required) |
|---|---|---|
| Patents, etc. (Applications as appropriate; implementation rights established) | Know-how (Designated by Director General after consideration of technological value; implementation rights established) | General technology information (Actively publicized; announced in large-scale project information materials and in scholarly conferences and journals) |

Methods of Implementing Results of Large-Scale Projects




Control of Results From Large-Scale Project System (when commissioned by government)




Control of Results From Large-Scale Project System (when commissioned by New Energy and Industrial Technology Development Organization)

Overview of Ownership of Industrial Property Rights

| Project name | R&D period | R&D cost | Budget category | Domestic patents | Foreign patents | Know-how designa-tions |
|---|---|---|---|---|---|---|
| (1) Very High-Performance Computers | FY 1966-71 | About ¥10.1 billion | Developed | 11 | 0 | -- |
| | | | Commissioned | 39 | 3 | 96 |
| | | | Total | 50 | 3 | 96 |
| (2) Desulfurization Technology | FY 1966-71 | About ¥2.7 billion | Developed | 4 | 1 | -- |
| | | | Commissioned | 9 | 4 | 21 |
| | | | Total | 13 | 5 | 21 |
| (3) New Olefin Production Method | FY 1967-72 | About ¥1.2 billion | Developed | 0 | 0 | -- |
| | | | Commissioned | 7 | 1 | 94 |
| | | | Total | 7 | 1 | 94 |
| (4) Remotely Operated Deep Sea Oil Drilling Equipment | FY 1970-75 | About ¥4.5 billion | Developed | 2 | 0 | -- |
| | | | Commissioned | 28 | 0 | 383 |
| | | | Total | 30 | 0 | 383 |
| (5) Desalination and Use of Byproducts | FY 1969-76 | About ¥6.7 billion | Developed | 10 | 0 | -- |
| | | | Commissioned | 19 | 3 | 83 |
| | | | Total | 29 | 3 | 83 |
| (6) Electric Automobile | FY 1971-76 | About ¥5.7 billion | Developed | 8 | 0 | -- |
| | | | Commissioned | 391 | 24 | 381 |
| | | | Total | 399 | 24 | 381 |
| (7) Automobile Management Technology | FY 1973-78 | About ¥7.3 billion | Developed | 5 | 0 | -- |
| | | | Commissioned | 43 | 0 | 313 |
| | | | Total | 48 | 0 | 313 |
| (8) Pattern Processing System | FY 1971-80 | About ¥21.9 billion | Developed | 49 | 9 | -- |
| | | | Commissioned | 326 | 13 | 761 |
| | | | Total | 375 | 22 | 761 |
| (9) Direct Steel-Making Using High-Temperature Reducing Gas | FY 1973-80 | About ¥13.7 billion | Developed | 0 | 0 | -- |
| | | | Commissioned | 43 | 6 | 168 |
| | | | Total | 43 | 6 | 168 |
| (10) Production of Olefins From Heavy Oil | FY 1975-81 | About ¥13.8 billion | Developed | 2 | 0 | -- |
| | | | Commissioned | 15 | 4 | 335 |
| | | | Total | 17 | 4 | 335 |
| (11) Jet Aircraft Engine | FY 1971-75 | About ¥13.8 billion | Developed | 0 | 0 | -- |
| | FY 1976-81 | About ¥12.9 billion | Commissioned | 12 | 0 | 322 |
| | | | Total | 12 | 0 | 322 |

| Project name | R&D period | R&D cost | Budget category | Domestic patents | Foreign patents | Know-how designations |
|---|---|---|---|---|---|---|
| (12) Energy Recycling Technology System | FY 1973-75 | About ¥1.3 billion | Developed | 22 | 0 | -- |
| | FY 1976-82 | About ¥11.3 billion | Commissioned | 226 | 35 | 274 |
| | | | Total | 248 | 35 | 274 |
| (13) High Performance Flexible Manufacturing System Complex Provided With Laser | FY 1977-84 | About ¥13.5 billion | Developed | 44 | 3 | -- |
| | | | Commissioned | 180 | 2 | 883 |
| | | | Total | 224 | 5 | 883 |
| (14) Seabed Petroleum Production System | FY 1978-84 | About ¥18.2 billion | Developed | 20 | 1 | -- |
| | | | Commissioned | 80 | 5 | 530 |
| | | | Total | 100 | 6 | 530 |
| (15) Optical Measurement and Control System | FY 1979-85 | About ¥15.7 billion | Developed | 51 | 8 | -- |
| | | | Commissioned | 446 | 6 | 676 |
| | | | Total | 497 | 14 | 676 |
| (16) One-Carbon-Molecule Chemical Technology | FY 1980-86 | About ¥10.6 billion | Developed | 83 | 8 | -- |
| | | | Commissioned | 236 | 29 | 332 |
| | | | Total | 319 | 37 | 332 |
| (17) Observation System for Earth Resources Satellite | FY 1984-88 | About ¥13.8 billion | Developed | 7 | 0 | -- |
| | | | Commissioned | 15 | 8 | 196 |
| | | | Total | 22 | 8 | 196 |
| (18) Manganese Nodule Mining System | FY 1981-91 | About ¥20.0 billion | Developed | 1 | 0 | -- |
| | | | Commissioned | 68 | 0 | 744 |
| | | | Total | 69 | 0 | 744 |
| (19) High-Speed Computer System for Scientific and Technological Uses | FY 1981-89 | About ¥23.0 billion | Developed | 50 | 0 | -- |
| | | | Commissioned | 361 | 8 | 161 |
| | | | Total | 411 | 8 | 161 |
| (20) Automated Sewing System | FY 1982-90 | About ¥10.0 billion | Developed | 31 | 2 | -- |
| | | | Commissioned | 185 | 0 | 252 |
| | | | Total | 216 | 2 | 252 |
| (21) Advanced Robot Technology | FY 1983-90 | About ¥20.0 billion | Developed | 60 | 7 | -- |
| | | | Commissioned | 252 | 7 | 267 |
| | | | Total | 312 | 14 | 267 |
| (22) New Water Treatment System | FY 1985-90 | About ¥11.8 billion | Developed | 4 | 0 | -- |
| | | | Commissioned | 2 | 0 | 14 |
| | | | Total | 6 | 0 | 14 |

| Project name | R&D period | R&D cost | Budget category | Domestic patents | Foreign patents | Know-how designa-tions |
|---|---|---|---|---|---|---|
| (23) Interoperable Database System | FY 1985-91 | About ¥15.0 billion | Developed | 3 | 0 | -- |
| | | | Commissioned | 9 | 0 | 12 |
| | | | Total | 12 | 0 | 12 |
| (24) Advanced Material Processing and Machining System | FY 1986-93 | About ¥13.8 billion | Developed | 12 | 0 | -- |
| | | | Commissioned | 12 | 0 | 0 |
| | | | Total | 24 | 0 | 0 |
| Total | | | Developed | 479 | 39 | -- |
| | | | Commissioned | 3,004 | 158 | 7,298 |
| | | | Total | 3,483 | 197 | 7,298 |

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